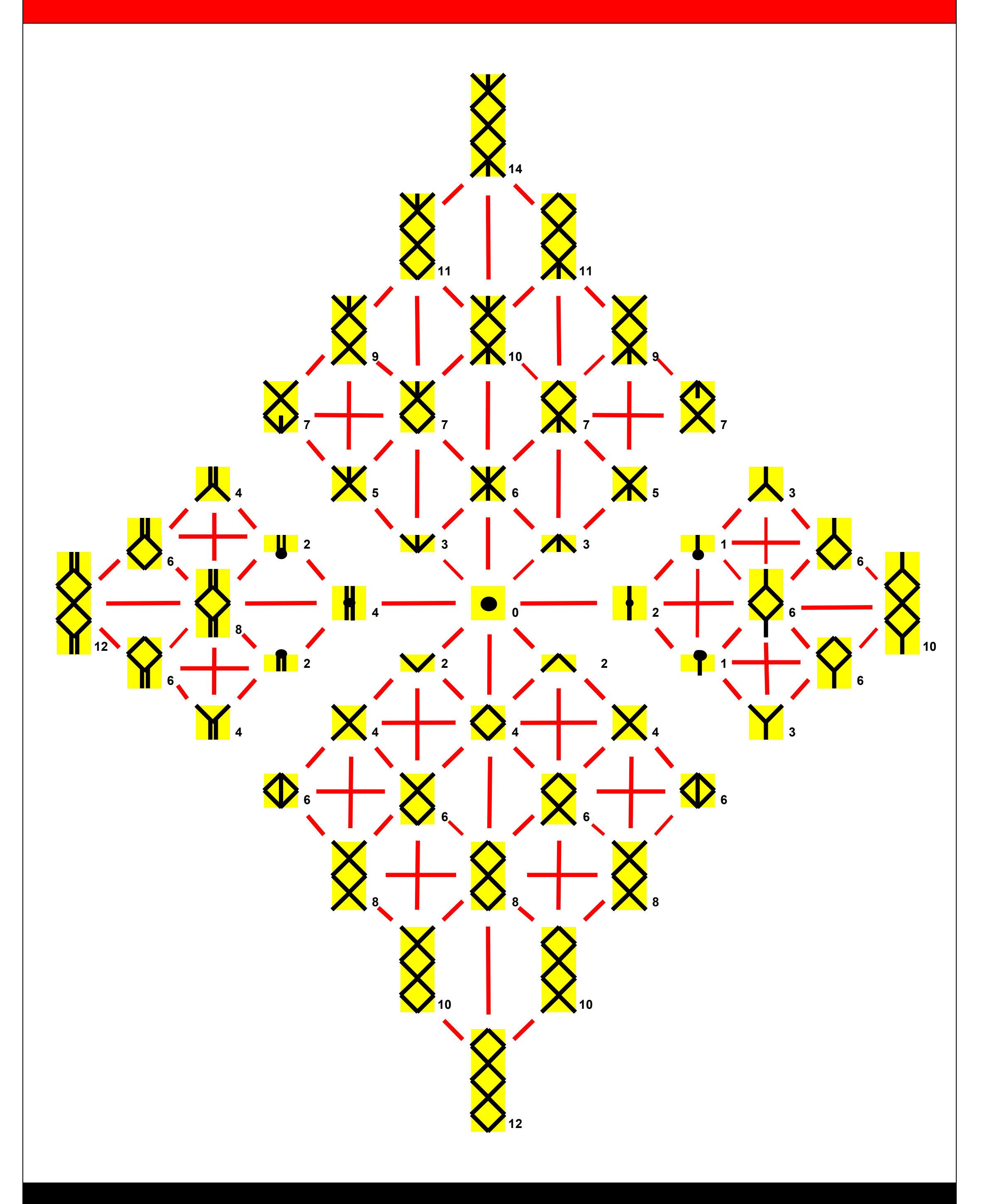
ESTRUCTURAS, SÍNTESIS Y ANÁLISIS DE PARTÍCULAS ELEMENTALES I



25-6-23 // 65-pg

ESTRUCTURAS, SÍNTESIS Y ANÁLISIS DE PARTÍCULAS ELEMENTALES

1 Síntesis de moléculas aromáticas

alfa-Pineno

H_2

Pinano

Craking

DH Mirceno

O

H OH

H_2O / SO_4H_2

O

H O

OH

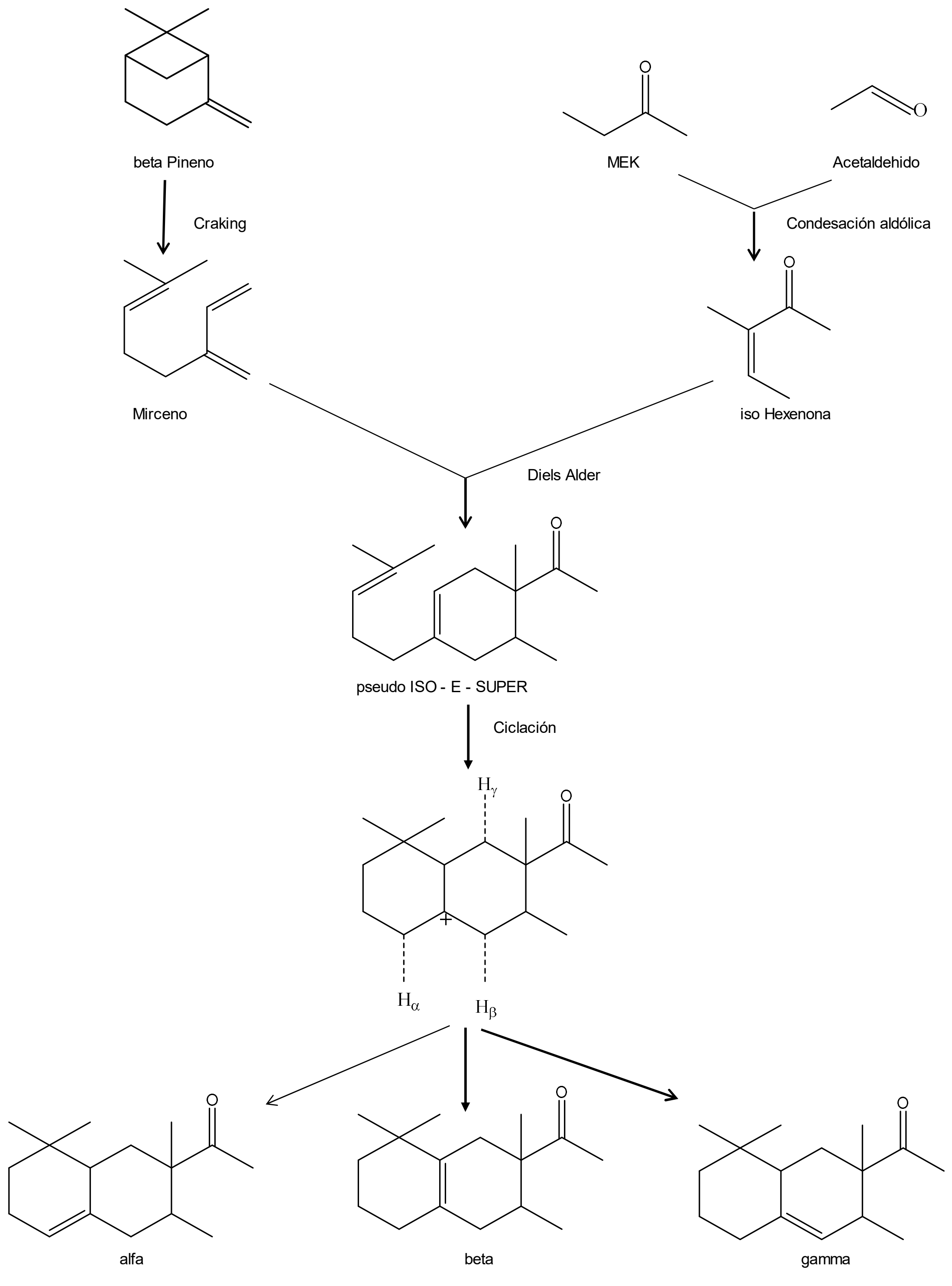
Saponificación

Formiato DH mircenilo

DH Mircenol

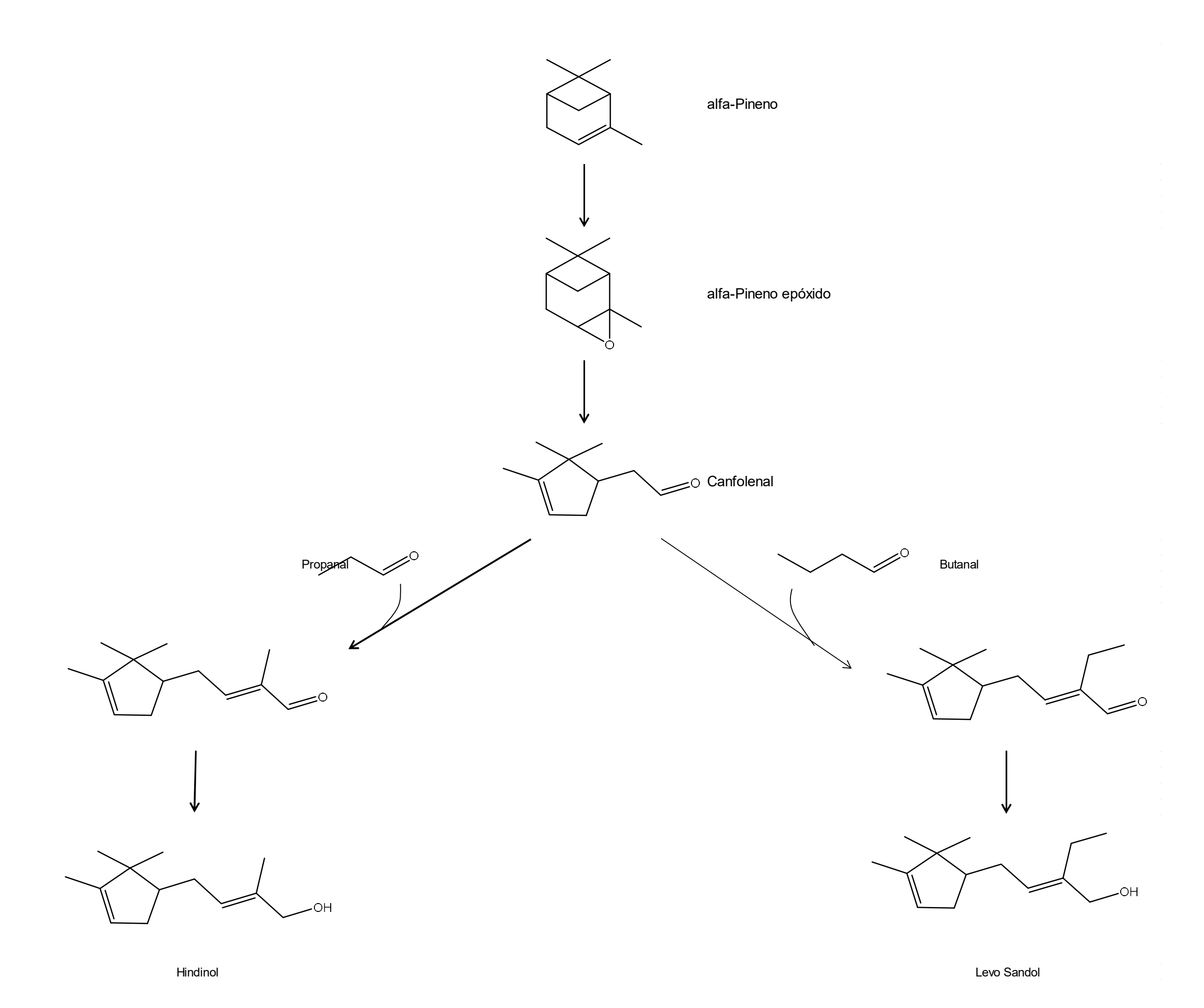
IFF (John H. Blumenthal - 1969)

DRT (1986)



ISO - E - SUPER

IFF (John B. Hall - 1975)


alfa-Pineno
alfa-Pineno epóxido
O
O
Canfolenal
Propanal
O
Butanal
O
O
O
OH
Hindinol
OH
Levo Sandol

Fenol

HO

SDM

Anisol

O

O

O

O

O

OH

O

O

H_2

OH

O

H_2O

Anetol

O

Butano

1,3-Butadieno

1,5-Ciclo octadieno

Ácido Fórmico

Ciclo octeno formiato

Carbonato de dimetilo

Formiato de metilo

Violiff

IFF (1981)

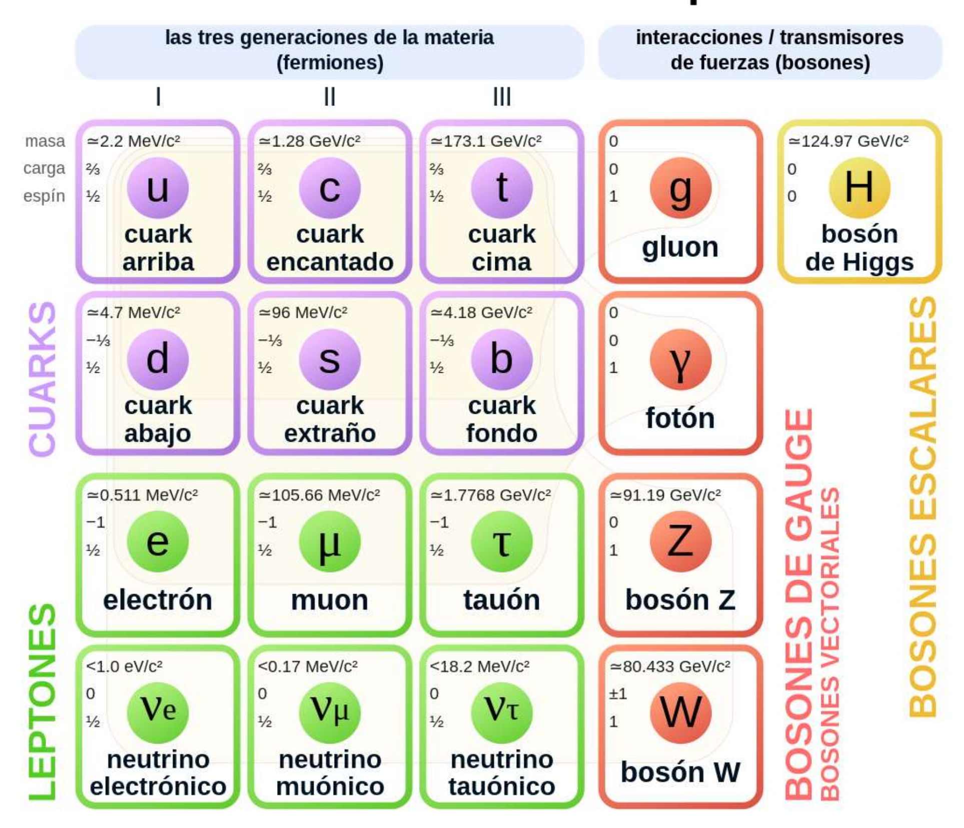
2 La Torre Periódica de los elementos

	14	32				70 Yb Iterbio	102 No Nobelio			
	13	31				69 Tm Tulio	101 Md Mendelevio			
	12	30				68 Er Erbio	100 Fm Fermio			
	11	29				67 Ho Holmio	99 Es Einstenio			
	10	28				66 Dy Disprosio	98 Cf Californio			
	9	27				65 Tb Terbio	97 Bk Berquelio			
	8	26				64 Gd Gadolinio	96 Cm Curio			
f	7	25				63 Eu Europio	95 Am Americio			
	6	24				62 Sm Samario	94 Pu Plutonio			
	5	23				61 Pm Prometeo	93 Np Neptunio			
	4	22				60 Nd Neodimio	92 U Uranio			
	3	21				59 Pr Praseodimio	91 Pa Protactinio			
	2	20				58 Ce Cerio	90 Th Torio			
	1	19				57 La Lantano	89 Ac Actinio			
	10	18			30 Zn Zinc	48 Cd Cadmio	80 Hg Mercurio	112 Cn Copernicio		
	9	17			29 Cu Cobre	47 Ag Plata	79 Au Oro	111 Rg Roentgenio		
	8	16			28 Ni Niquel	46 Pd Paladio	78 Pt Platino	110 Ds Darmstadtio		
	7	15			27 Co Cobalto	45 Rh Rodio	77 Ir Iridio	109 Mt Meterio		
	6	14			26 Fe Hierro	44 Ru Rutenio	76 Os Osmio	108 Hs Hasio		
d	5	13			25 Mn Manganeso	43 Tc Tecnecio	75 Re Renio	107 Bh Bohrio		
	4	12			24 Cr Cromo	42 Mo Molibdeno	74 W Wolframio	106 Sg Seaborgio		
	3	11			23 V Vanadio	41 Nb Niobio	73 Ta Tántalo	105 Db Dubnio		
	2	10			22 Ti Titanio	40 Zr Zirconio	72 Hf Hafnio	104 Rf Rutherfonio		
	1	9			21 Sc Scandio	39 Y Itrio	71 Lu Lutecio	103 Lr Lawrencio		
	6	8		10 Ne Neon	18 Ar Argón	36 Kr Kripton	54 Xe Xenon	86 Rn Ranon	118 Og Oganesón	
	5	7		9 F Fluor	17 Cl Cloro	35 Br Bromo	53 I Yodo	85 At Astato	117 Ts Téneso	
	4	6		8 O Oxígeno	16 S Azufre	34 Se Selenio	52 Te Teluro	84 Po Polonio	116 Lv Livermorio	
p	3	5		7 N Nitrógeno	15 P Fósforo	33 As Arsénico	51 Sb Antimónio	83 Bi Bismuto	115 Mc Moscovio	
	2	4		6 C Carbono	14 Si Silicio	32 Ge Germanio	50 Sn Estaño	82 Pb Plomo	114 Fl Flerovio	
	1	3		5 B Boro	13 Al Aluminio	31 Ga Galio	49 In Indio	81 Tl Talio	113 Uut Nihonio	
s	2	2	2 He Helio	4 Be Berilio	12 Mg Magnesio	20 Ca Calcio	38 Sr Estróncio	56 Ba Bario	88 Ra Radio	120 Ubn Unbinilio
	1	1	1 H Hidrógeno	3 Li Litio	11 Na Sodio	19 K Potasio	37 Rb Rubídio	55 Cs Cesio	87 Fr Francio	119 Uue Ununhenio
			1	2	3	4	5	6	7	8

	18	50					138	188				
	17	49					137	187				
	16	48					136	186				
	15	47					135	185				
	14	46					134	184				
	13	45					133	183				
	12	44					132	182				
	11	43					131	181				
g	10	42					130	180				
	9	41					129	179				
	8	40					128	178				
	7	39					127	177				
	6	38					126	176				
	5	37					125	175				
	4	36					124	174				
	3	35					123	173				
	2	34					122	172				
	1	33					121	171				
	14	32				70 Yb Iterbio	102 No Nobelio	152	202			
	13	31				69 Tm Tulio	101 Md Mendelevio	151	201			
	12	30				68 Er Erbio	100 Fm Fermio	150	200			
	11	29				67 Ho Holmio	99 Es Einstenio	149	199			
	10	28				66 Dy Disprosio	98 Cf Californio	148	198			
	9	27				65 Tb Terbio	97 Bk Berquelio	147	197			
f	8	26				64 Gd Gadolinio	96 Cm Curio	146	196			
	7	25				63 Eu Europio	95 Am Americio	145	195			
	6	24				62 Sm Samario	94 Pu Plutonio	144	194			
	5	23				61 Pm Prometeo	93 Np Neptunio	143	193			
	4	22				60 Nd Neodimio	92 U Uranio	142	192			
	3	21				59 Pr Praseodimio	91 Pa Protactinio	141	191			
	2	20				58 Ce Cerio	90 Th Torio	140	190			
	1	19				57 La Lantano	89 Ac Actinio	139	189			
	10	18			30 Zn Zinc	48 Cd Cadmio	80 Hg Mercurio	112 Cn Copernicio	162	212		
	9	17			29 Cu Cobre	47 Ag Plata	79 Au Oro	111 Rg Roentgenio	161	211		
	8	16			28 Ni Niquel	46 Pd Paladio	78 Pt Platino	110 Ds Darmstadtio	160	210		
	7	15			27 Co Cobalto	45 Rh Rodio	77 Ir Iridio	109 Mt Meterio	159	209		
d	6	14			26 Fe Hierro	44 Ru Rutenio	76 Os Osmio	108 Hs Hasio	158	208		
	5	13			25 Mn Manganeso	43 Tc Tecnecio	75 Re Renio	107 Bh Bohrio	157	207		
	4	12			24 Cr Cromo	42 Mo Molibdeno	74 W Wolframio	106 Sg Seaborgio	156	206		
	3	11			23 V Vanadio	41 Nb Niobio	73 Ta Tántalo	105 Db Dubnio	155	205		
	2	10			22 Ti Titanio	40 Zr Zirconio	72 Hf Hafnio	104 Rf Rutherfonio	154	204		
	1	9			21 Sc Scandio	39 Y Itrio	71 Lu Lutecio	103 Lr Lawrencio	153	203		
	6	8		10 Ne Neon	18 Ar Argón	36 Kr Kripton	54 Xe Xenon	86 Rn Ranon	118 Og Oganesón	168	218	
	5	7		9 F Fluor	17 Cl Cloro	35 Br Bromo	53 I Yodo	85 At Astato	117 Ts Téneso	167	217	
	4	6		8 O Oxigeno	16 S Azufre	34 Se Selenio	52 Te Teluro	84 Po Polonio	116 Lv Livermorio	166	216	
p	3	5		7 N Nitrógeno	15 P Fósforo	33 As Arsénico	51 Sb Antimónio	83 Bi Bismuto	115 Mc Moscovio	165	215	
	2	4		6 C Carbono	14 Si Silicio	32 Ge Germanio	50 Sn Estaño	82 Pb Plomo	114 Fl Flerovio	164	214	
	1	3		5 B Boro	13 Al Aluminio	31 Ga Galio	49 In Indio	81 Tl Talio	113 Uut Nihonio	163	213	
s	2	2	2 He Helio	4 Be Berilio	12 Mg Magnesio	20 Ca Calcio	38 Sr Estróncio	56 Ba Bario	88 Ra Radio	120 Ubn Unbinilio	170	220
	1	1	1 H Hidrógeno	3 Li Litio	11 Na Sodio	19 K Potasio	37 Rb Rubidio	55 Cs Cesio	87 Fr Francio	119 Uue Ununhenio	169	219
			1	2	3	4	5	6	7	8	9	10

h	22	72						242	314					
	21	71						241	313					
	20	70						240	312					
	19	69						239	311					
	18	68						238	310					
	17	67						237	309					
	16	66						236	308					
	15	65						235	307					
	14	64						234	306					
	13	63						233	305					
	12	62						232	304					
	11	61						231	303					
	10	60						230	302					
	9	59						229	301					
	8	58						228	300					
	7	57						227	299					
	6	56						226	298					
	5	55						225	297					
	4	54						224	296					
	3	53						223	295					
	2	52						222	294					
	1	51						221	293					
g	18	50					138	188	260	332				
	17	49					137	187	259	331				
	16	48					136	186	258	330				
	15	47					135	185	257	329				
	14	46					134	184	256	328				
	13	45					133	183	255	327				
	12	44					132	182	254	326				
	11	43					131	181	253	325				
	10	42					130	180	252	324				
	9	41					129	179	251	323				
	8	40					128	178	250	322				
	7	39					127	177	249	321				
	6	38					126	176	248	320				
	5	37					125	175	247	319				
	4	36					124	174	246	318				
	3	35					123	173	245	317				
	2	34					122	172	244	316				
	1	33					121	171	243	315				
f	14	32				70 Yb Iterbio	102 No Nobelio	152	202	274	346			
	13	31				69 Tm Tulio	101 Md Mendelevio	151	201	273	345			
	12	30				68 Er Erbio	100 Fm Fermio	150	200	272	344			
	11	29				67 Ho Holmio	99 Es Einstenio	149	199	271	343			
	10	28				66 Dy Disprosio	98 Cf Californio	148	198	270	342			
	9	27				65 Tb Terbio	97 Bk Berquelio	147	197	269	341			
	8	26				64 Gd Gadolinio	96 Cm Curio	146	196	268	340			
	7	25				63 Eu Europio	95 Am Americio	145	195	267	339			
	6	24				62 Sm Samario	94 Pu Plutonio	144	194	266	338			
	5	23				61 Pm Prometeo	93 Np Neptunio	143	193	265	337			
	4	22				60 Nd Neodimio	92 U Uranio	142	192	264	336			
	3	21				59 Pr Praseodimio	91 Pa Protactinio	141	191	263	335			
	2	20				58 Ce Cerio	90 Th Torio	140	190	262	334			
	1	19				57 La Lantano	89 Ac Actinio	139	189	261	333			
d	10	18			30 Zn Zinc	48 Cd Cadmio	80 Hg Mercurio	112 Cn Copernicio	162	212	284	356		
	9	17			29 Cu Cobre	47 Ag Plata	79 Au Oro	111 Rg Roentgenio	161	211	283	355		
	8	16			28 Ni Niquel	46 Pd Paladio	78 Pt Platino	110 Ds Darmstadtio	160	210	282	354		
	7	15			27 Co Cobalto	45 Rh Rodio	77 Ir Iridio	109 Mt Meterio	159	209	281	353		
	6	14			26 Fe Hierro	44 Ru Rutenio	76 Os Osmio	108 Hs Hasio	158	208	280	352		
	5	13			25 Mn Manganeso	43 Tc Tecnecio	75 Re Renio	107 Bh Bohrio	157	207	279	351		
	4	12			24 Cr Cromo	42 Mo Molibdeno	74 W Wolframio	106 Sg Seaborgio	156	206	278	350		
	3	11			23 V Vanadio	41 Nb Niobio	73 Ta Tántalo	105 Db Dubnio	155	205	277	349		
	2	10			22 Ti Titanio	40 Zr Zirconio	72 Hf Hafnio	104 Rf Rutherfonio	154	204	276	348		
	1	9			21 Sc Scandio	39 Y Itrio	71 Lu Lutecio	103 Lr Lawrencio	153	203	275	347		
p	6	8		10 Ne Neon	18 Ar Argón	36 Kr Kripton	54 Xe Xenon	86 Rn Ranon	118 Og Oganesón	168	218	290	362	
	5	7		9 F Fluor	17 Cl Cloro	35 Br Bromo	53 I Yodo	85 At Astato	117 Ts Téneso	167	217	289	361	
	4	6		8 O Oxígeno	16 S Azufre	34 Se Selenio	52 Te Teluro	84 Po Polonio	116 Lv Livermorio	166	216	288	360	
	3	5		7 N Nitrógeno	15 P Fósforo	33 As Arsénico	51 Sb Antimónio	83 Bi Bismuto	115 Mc Moscovio	165	215	287	359	
	2	4		6 C Carbono	14 Si Silicio	32 Ge Germanio	50 Sn Estaño	82 Pb Plomo	114 Fl Flerovio	164	214	286	358	
	1	3		5 B Boro	13 Al Aluminio	31 Ga Galio	49 In Indio	81 Tl Talio	113 Uut Nihonio	163	213	285	357	
s	2	2	2 He Helio	4 Be Berilio	12 Mg Magnesio	20 Ca Calcio	38 Sr Estróncio	56 Ba Bario	88 Ra Radio	120 Ubn Unbinilio	170	220	292	364
	1	1	1 H Hidrógeno	3 Li Litio	11 Na Sodio	19 K Potasio	37 Rb Rubidio	55 Cs Cesio	87 Fr Francio	119 Uue Ununhenio	169	219	291	363
			1	2	3	4	5	6	7	8	9	10	11	12

3 El Modelo Estándar de las partículas (ME)

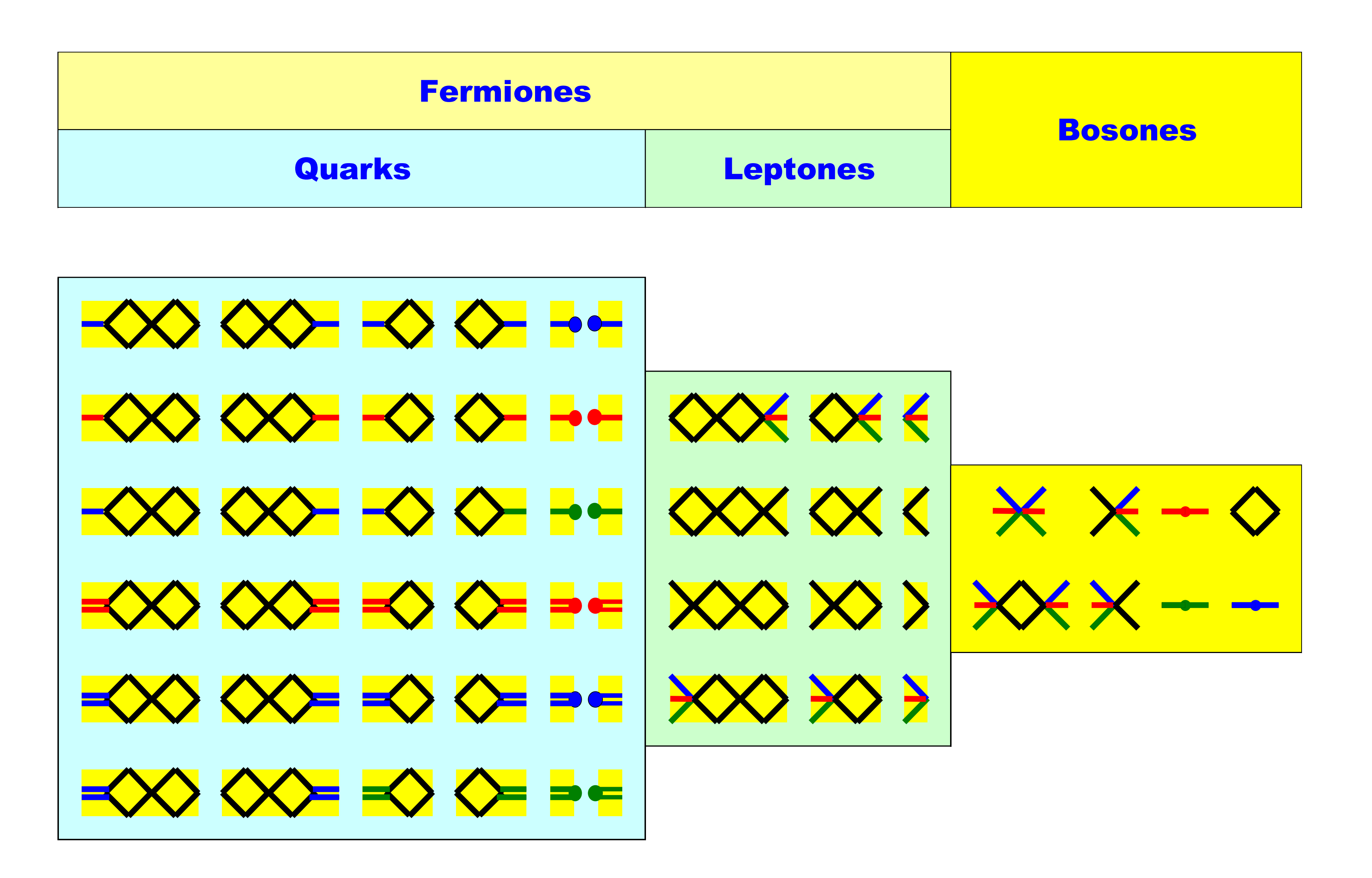


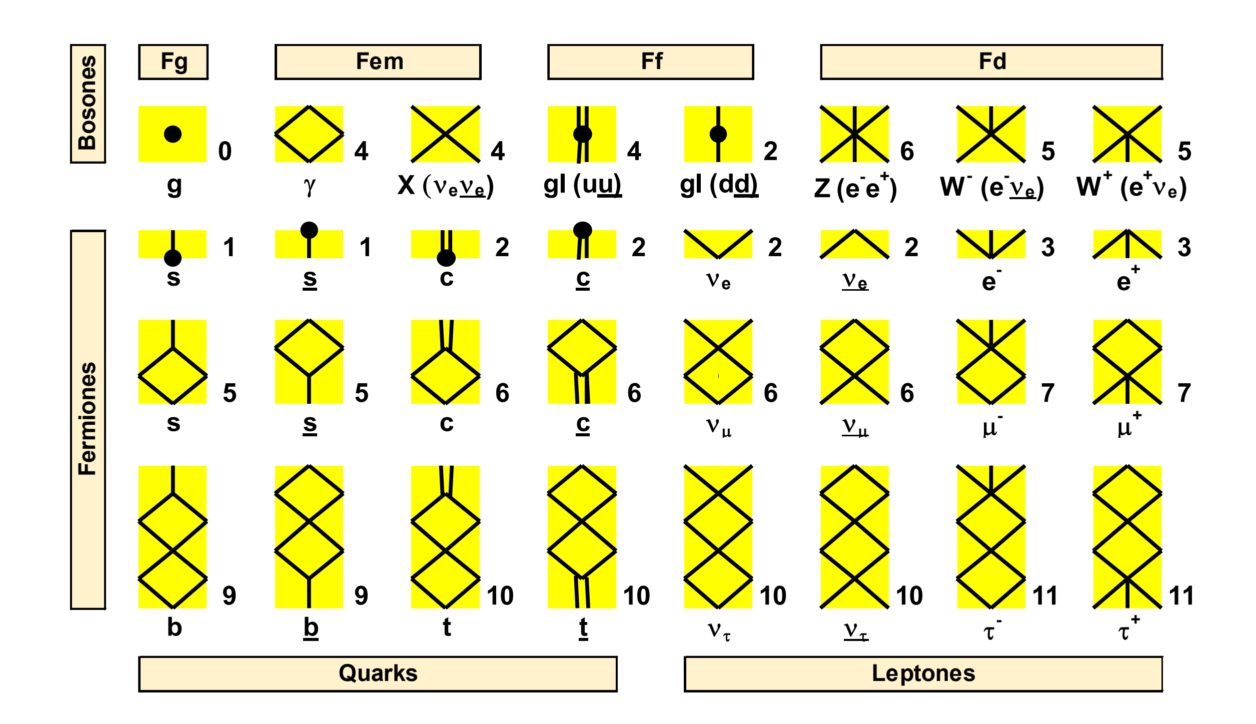
		Bosones			
		γ	gl	W	Z
Fermiones	I	d	u	e	ν_e
	II	s	c	μ	ν_μ
	III	b	t	τ	ν_τ
		Quarks		Leptones	

4 Estructuras de las partículas del ME

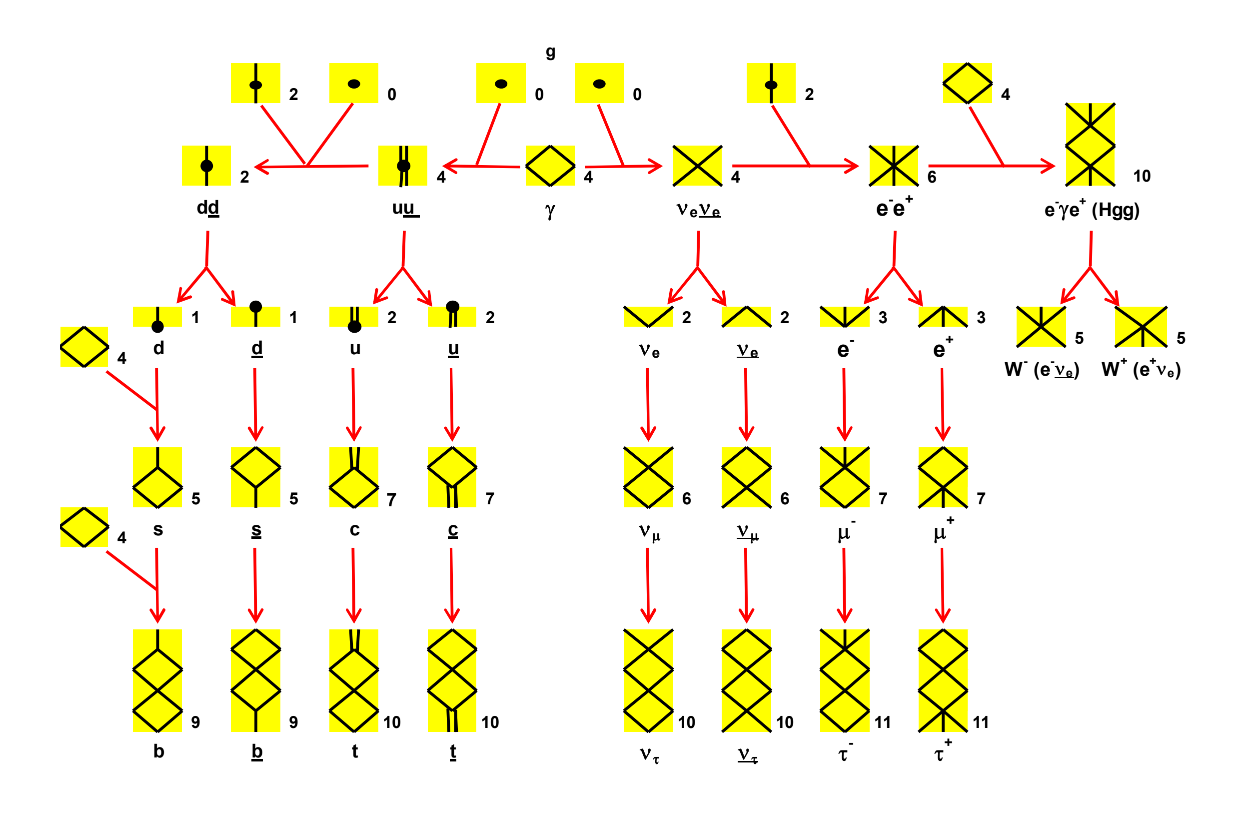
			Bosones						
			γ	gl	W^-	W^+	Z	H_g	
Fermiones	I	$d^{-1/3}$	$u^{-2/3}$	$u^{+2/3}$	$d^{+1/3}$	e^-	ν_e	$\underline{\nu}_e$	e^+
	II	$s^{-1/3}$	$c^{-2/3}$	$c^{+2/3}$	$s^{+1/3}$	μ^-	ν_μ	$\underline{\nu}_\mu$	μ^+
	III	$b^{-1/3}$	$t^{-2/3}$	$t^{+2/3}$	$t^{+1/3}$	τ^-	ν_τ	$\underline{\nu}_\tau$	τ^+
		Quarks				Leptones			

Bosones				γ	gl		
				W^-	W^+		
				Z	H_{gg}		
Fermiones	Leptones		e^-	ν_e	$\underline{\nu}_e$	e^+	
			μ^-	ν_μ	$\underline{\nu}_\mu$	μ^+	
			τ^-	ν_τ	$\underline{\nu}_\tau$	τ^+	
	Quarks	$d^{-1/3}$	$d^{-1/3}$	$d^{-1/3}$	$u^{-2/3}$	$u^{-2/3}$	$u^{-2/3}$
		$d^{+1/3}$	$d^{+1/3}$	$d^{+1/3}$	$u^{+2/3}$	$u^{+2/3}$	$u^{+2/3}$
		$s^{-1/3}$	$s^{-1/3}$	$s^{-1/3}$	$c^{-2/3}$	$c^{-2/3}$	$c^{-2/3}$
		$s^{+1/3}$	$s^{+1/3}$	$s^{+1/3}$	$c^{+2/3}$	$c^{+2/3}$	$c^{+2/3}$
		$b^{-1/3}$	$b^{-1/3}$	$b^{-1/3}$	$t^{-2/3}$	$t^{-2/3}$	$t^{-2/3}$
		$t^{+1/3}$	$t^{+1/3}$	$t^{+1/3}$	$t^{+2/3}$	$t^{+2/3}$	$t^{+2/3}$

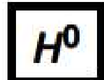

Fermiones
Quarks
Leptones
Bosones



5 Síntesis de las partículas del ME



6 El bosón de Higgs



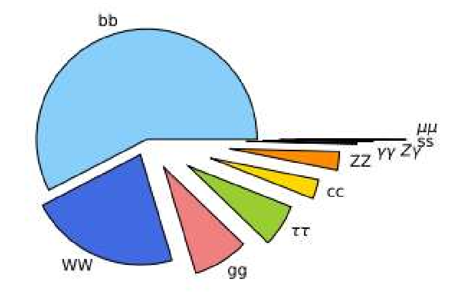
Mass $m = 125.25 \pm 0.17$ GeV (S = 1.5)
Full width $\Gamma = 3.2^{+2.8}_{-2.2}$ MeV (assumes equal on-shell and off-shell effective couplings)

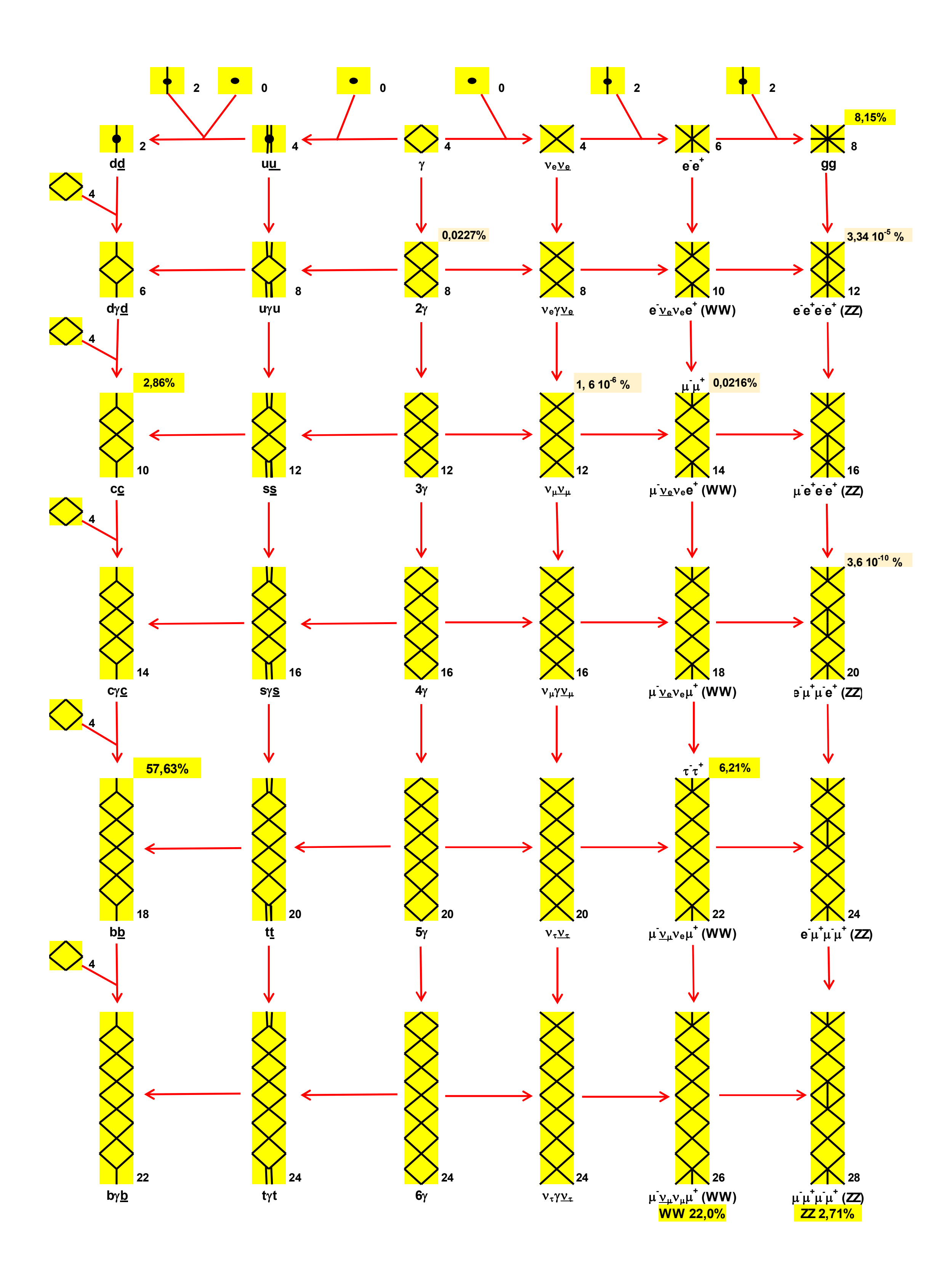
H^0 Signal Strengths in Different Channels

Combined Final States = 1.13 ± 0.06
$W W^* = 1.19 \pm 0.12$
$Z Z^* = 1.01 \pm 0.07$
$\gamma\gamma = 1.10 \pm 0.07$
$c\overline{c}$ Final State = 37 ± 20
$b\overline{b} = 0.98 \pm 0.12$
$\mu^+\mu^- = 1.19 \pm 0.34$
$\tau^+\tau^- = 1.15^{+0.16}_{-0.15}$
$Z\gamma <$ 3.6, CL = 95%

H^0 Production Cross Section in pp Collisions at $\sqrt{s} = 13$ TeV

Decay channel	Branching fraction (%)
bb	57.63 ± 0.70
WW	22.00 ± 0.33
gg	8.15 ± 0.42
$\tau\tau$	6.21 ± 0.09
cc	2.86 ± 0.09
ZZ	2.71 ± 0.04
$\gamma\gamma$	0.227 ± 0.005
$Z\gamma$	0.157 ± 0.009
ss	0.025 ± 0.001
$\mu\mu$	0.0216 ± 0.0004




2
0
0
0
2
2
8,15%
2
dd
4
uu
4
γ
4
νeνe
6
e-e+
8
gg
4
0,0227%
3,34 10-5 %
6
dγd
8
uγu
8
2γ
8
νeγνe
10
e-νeνee+ (WW)
12
e-e+e-e+ (ZZ)
4
2,86%
1, 6 10-6 %
μ-μ+
0,0216%
10
cc
12
ss
12
3γ
12
νμνμ
14
μ-νeνee+ (WW)
16
μ-e+e-e+ (ZZ)
4
3,6 10-10 %
14
cγc
16
sγs
16
4γ
16
νμγνμ
18
μ-νeνeμ+ (WW)
20
e-μ+μ-e+ (ZZ)
4
57,63%
τ-τ+
6,21%
18
bb
20
tt
20
5γ
20
ντντ
22
μ-νμνeμ+ (WW)
24
e-μ+μ-μ+ (ZZ)
4
22
bγb
24
tγt
24
6γ
24
ντγντ
26
μ-νμνμμ+ (WW)
WW 22,0%
28
μ-μ+μ-μ+ (ZZ)
ZZ 2,71%

W

Charge = $\pm 1\ e$
Mass $m = 80.377 \pm 0.012$ GeV

W^- modes are charge conjugates of the modes below.

W^+ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$e^+\nu$	(10.71 ± 0.16) %	40189
$\mu^+\nu$	(10.63 ± 0.15) %	40189
$\tau^+\nu$	(11.38 ± 0.21) %	40170
hadrons	(67.41 ± 0.27) %	–

Z

Charge = 0
Mass $m = 91.1876 \pm 0.0021$ GeV

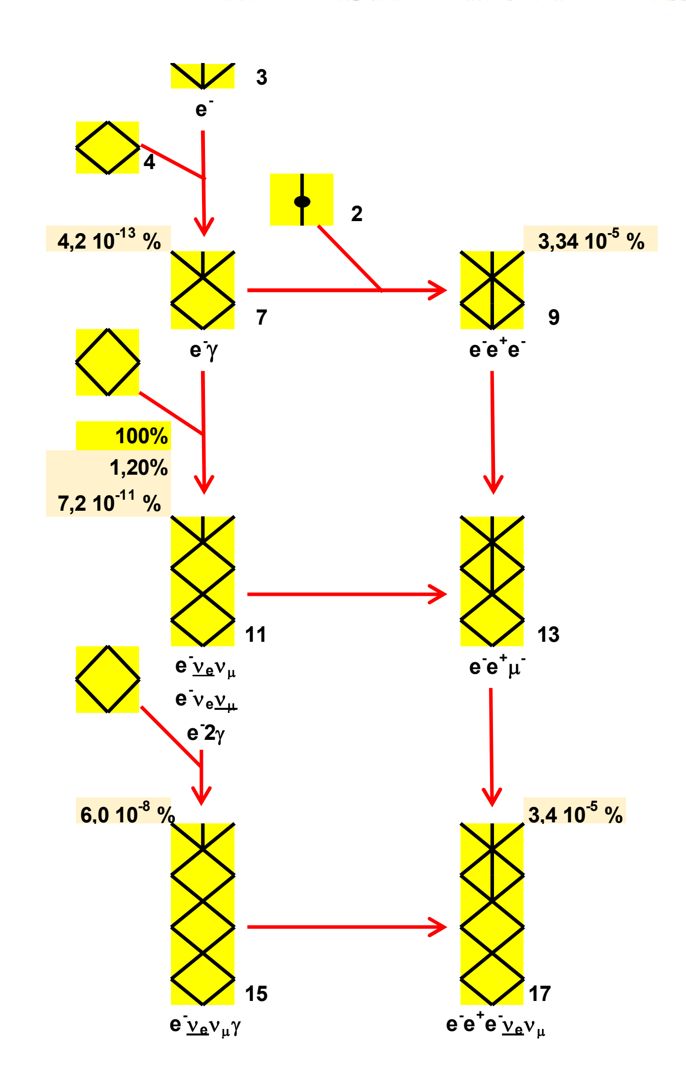
Z DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
e^+e^-	(3.3632 ± 0.0042) %	45594
$\mu^+\mu^-$	(3.3662 ± 0.0066) %	45594
$\tau^+\tau^-$	(3.3696 ± 0.0083) %	45559
invisible	(20.000 ± 0.055) %	–
hadrons	(69.911 ± 0.056) %	–

7 El muón

μ

Mass $m = 0.1134289259 \pm 0.0000000025$ u
Mass $m = 105.6583755 \pm 0.0000023$ MeV
Mean life $\tau = (2.1969811 \pm 0.0000022) \times 10^{-6}$ s
$\tau_{\mu^+}/\tau_{\mu^-} = 1.00002 \pm 0.00008$
$c\tau = 658.6384$ m

μ^- **DECAY MODES**		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$e^- \overline{\nu}_e \nu_\mu$		$\approx 100\%$		53
$e^- \overline{\nu}_e \nu_\mu \gamma$		[d] $(6.0 \pm 0.5) \times 10^{-8}$		53
$e^- \overline{\nu}_e \nu_\mu e^+ e^-$		[e] $(3.4 \pm 0.4) \times 10^{-5}$		53
Lepton Family number (*LF*) violating modes				
$e^- \nu_e \overline{\nu}_\mu$	*LF*	[f] < 1.2 %	90%	53
$e^- \gamma$	*LF*	$< 4.2 \times 10^{-13}$	90%	53
$e^- e^+ e^-$	*LF*	$< 1.0 \times 10^{-12}$	90%	53
$e^- 2\gamma$	*LF*	$< 7.2 \times 10^{-11}$	90%	53

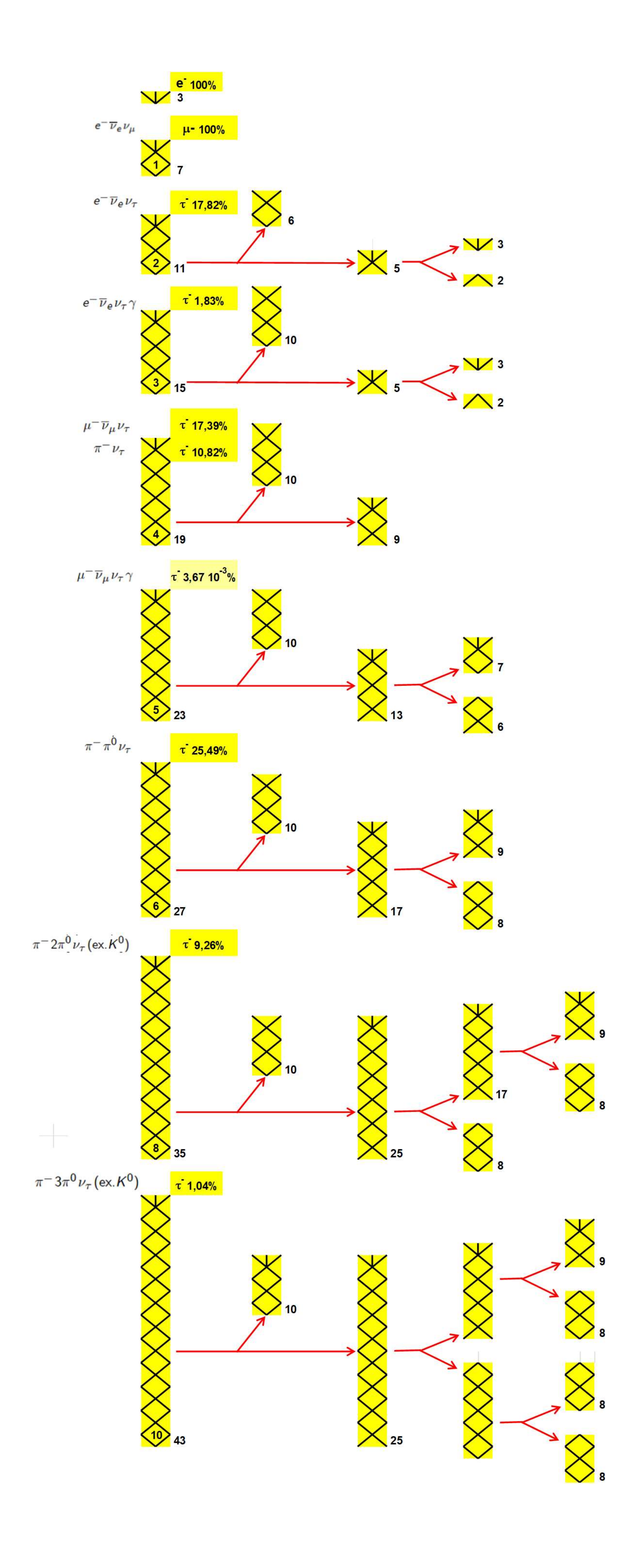


8 El tauón

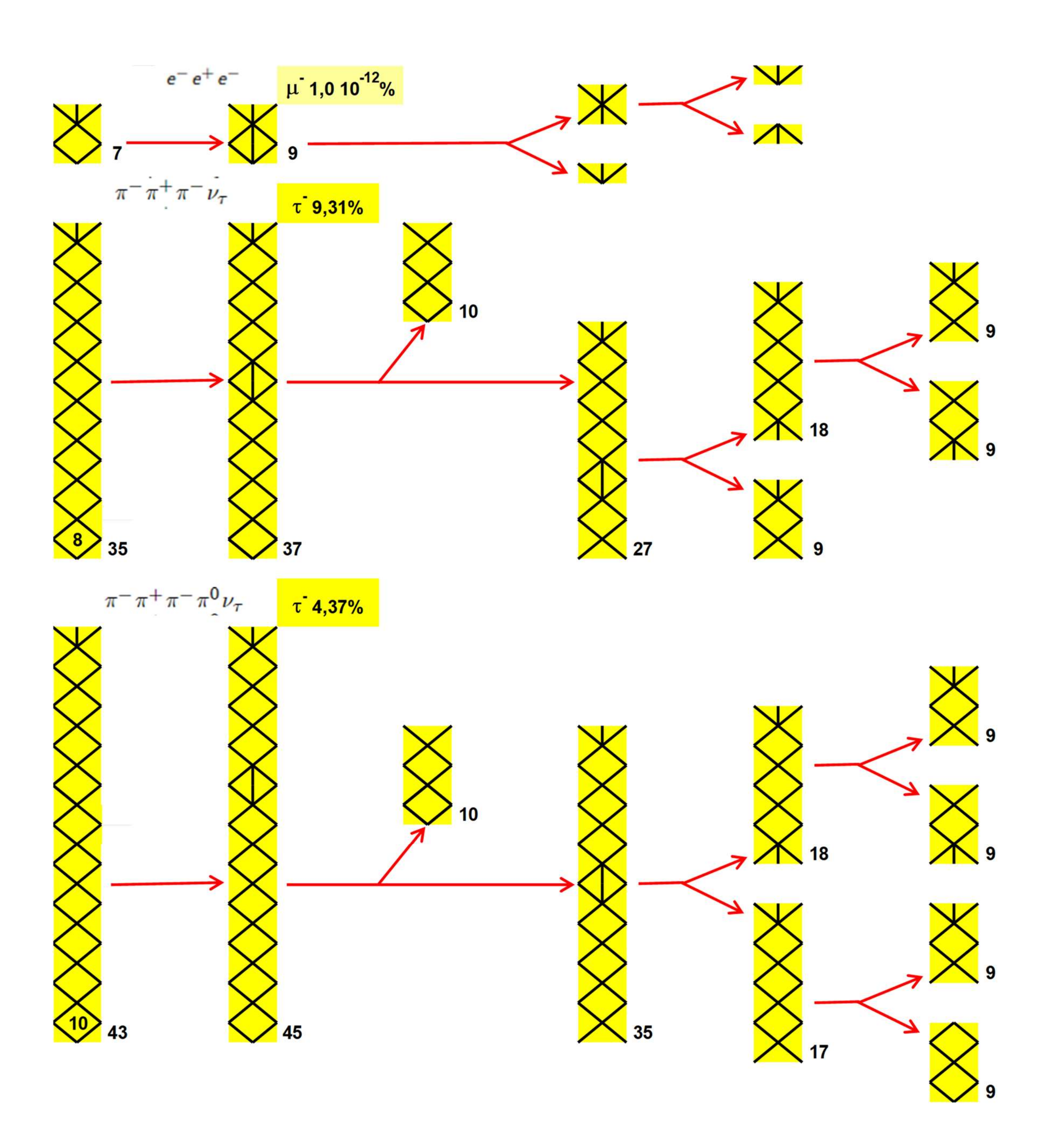
τ

Mass $m = 1776.86 \pm 0.12$ MeV
$(m_{\tau^+} - m_{\tau^-})/m_{\text{average}} < 2.8 \times 10^{-4}$, CL = 90%
Mean life $\tau = (290.3 \pm 0.5) \times 10^{-15}$ s
$c\tau = 87.03\ \mu$m

τ^- DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
Modes with one charged particle		
$\mu^-\overline{\nu}_\mu\nu_\tau$	(17.39 ± 0.04) %	885
$\mu^-\overline{\nu}_\mu\nu_\tau\gamma$	$(3.67 \pm 0.08) \times 10^{-3}$	885
$e^-\overline{\nu}_e\nu_\tau$	(17.82 ± 0.04) %	888
$e^-\overline{\nu}_e\nu_\tau\gamma$	(1.83 ± 0.05) %	888
$\pi^-\nu_\tau$	(10.82 ± 0.05) %	883
$K^-\nu_\tau$	$(6.96 \pm 0.10) \times 10^{-3}$	820
$\pi^-\pi^0\nu_\tau$	(25.49 ± 0.09) %	878
$\pi^-2\pi^0\nu_\tau$ (ex. K^0)	(9.26 ± 0.10) %	862
$\pi^-3\pi^0\nu_\tau$ (ex. K^0)	(1.04 ± 0.07) %	836
$K^-3\pi^0\nu_\tau$ (ex. K^0, η)	$(4.8 \pm 2.1) \times 10^{-4}$	765
Modes with three charged particles		
$\pi^-\pi^+\pi^-\nu_\tau$	(9.31 ± 0.05) %	861
$\pi^-\pi^+\pi^-\nu_\tau$ (ex. K^0)	(9.02 ± 0.05) %	861
$\pi^-\pi^+\pi^-\nu_\tau$ (ex. K^0,ω)	(8.99 ± 0.05) %	861
$\pi^-\pi^+\pi^-\pi^0\nu_\tau$	(4.62 ± 0.05) %	834
$\pi^-\pi^+\pi^-\pi^0\nu_\tau$ (ex. K^0)	(4.49 ± 0.05) %	834
$\pi^-\pi^+\pi^-\pi^0\nu_\tau$ (ex. K^0,ω)	(2.74 ± 0.07) %	834



e⁻ 100%
3
$e^-\overline{\nu}_e\nu_\mu$
μ- 100%
1
7
$e^-\overline{\nu}_e\nu_\tau$
τ⁻ 17,82%
2
11
6
5
3
2
$e^-\overline{\nu}_e\nu_\tau\gamma$
τ⁻ 1,83%
3
15
10
5
3
2
$\mu^-\overline{\nu}_\mu\nu_\tau$
$\pi^-\nu_\tau$
τ⁻ 17,39%
τ⁻ 10,82%
4
19
10
9
$\mu^-\overline{\nu}_\mu\nu_\tau\gamma$
τ⁻ 3,67 10⁻³%
5
23
10
13
7
6
$\pi^-\pi^0\nu_\tau$
τ⁻ 25,49%
6
27
10
17
9
8
$\pi^-2\pi^0\nu_\tau$(ex.K^0)
τ⁻ 9,26%
8
35
10
25
17
8
9
8
$\pi^-3\pi^0\nu_\tau$(ex.K^0)
τ⁻ 1,04%
10
43
10
25
9
8
8
8



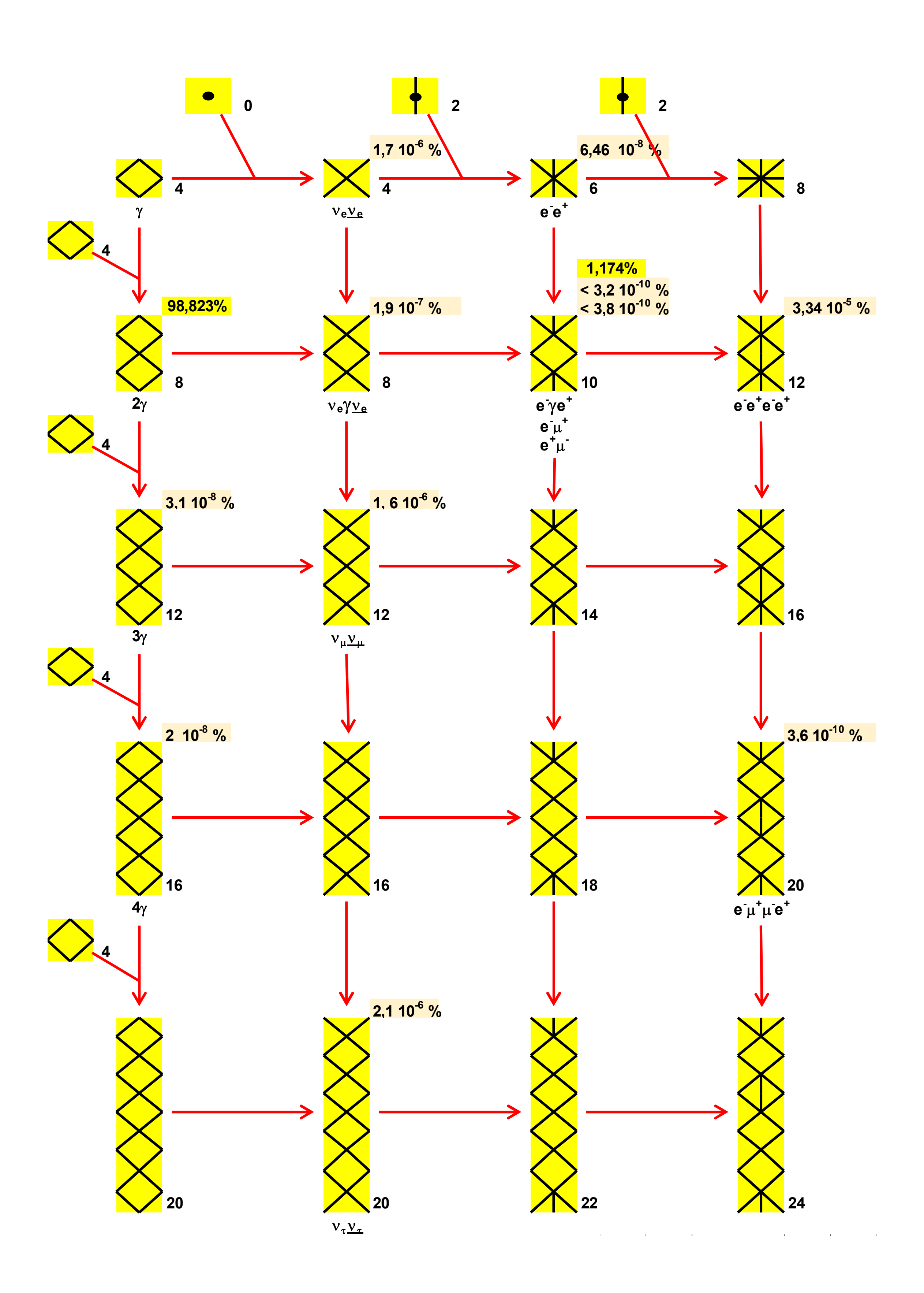
$e^- e^+ e^-$
μ⁻ 1,0 10⁻¹²%
7
9
$\pi^- \pi^+ \pi^- \nu_\tau$
τ⁻ 9,31%
8
35
37
10
27
18
9
9
9
$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$
τ⁻ 4,37%
10
43
45
10
35
18
17
9
9
9
9

9 Los mesones Pi

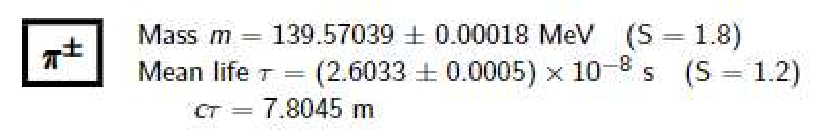


Mass $m = 134.9768 \pm 0.0005$ MeV
$m_{\pi^\pm} - m_{\pi^0} = 4.5936 \pm 0.0005$ MeV
Mean life $\tau = (8.43 \pm 0.13) \times 10^{-17}$ s
$c\tau = 25.3$ nm

π^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
2γ		(98.823 ± 0.034) %	S=1.5	67
$e^+ e^- \gamma$		(1.174 ± 0.035) %	S=1.5	67
γ positronium		$(1.82 \pm0.29) \times 10^{-9}$		67
$e^+ e^+ e^- e^-$		$(3.34 \pm0.16) \times 10^{-5}$		67
$e^+ e^-$		$(6.46 \pm0.33) \times 10^{-8}$		67
4γ		$< 2 \times 10^{-8}$	CL=90%	67
$\nu\overline{\nu}$		$< 4.4 \times 10^{-9}$	CL=90%	67
$\nu_e\overline{\nu}_e$		$< 1.7 \times 10^{-6}$	CL=90%	67
$\nu_\mu\overline{\nu}_\mu$		$< 1.6 \times 10^{-6}$	CL=90%	67
$\nu_\tau\overline{\nu}_\tau$		$< 2.1 \times 10^{-6}$	CL=90%	67
$\gamma\nu\overline{\nu}$		$< 1.9 \times 10^{-7}$	CL=90%	67
Charge conjugation (*C*) or Lepton Family number (*LF*) violating modes				
3γ	*C*	$< 3.1 \times 10^{-8}$	CL=90%	67
$\mu^+ e^-$	*LF*	$< 3.8 \times 10^{-10}$	CL=90%	26
$\mu^- e^+$	*LF*	$< 3.2 \times 10^{-10}$	CL=90%	26
$\mu^+ e^- + \mu^- e^+$	*LF*	$< 3.6 \times 10^{-10}$	CL=90%	26



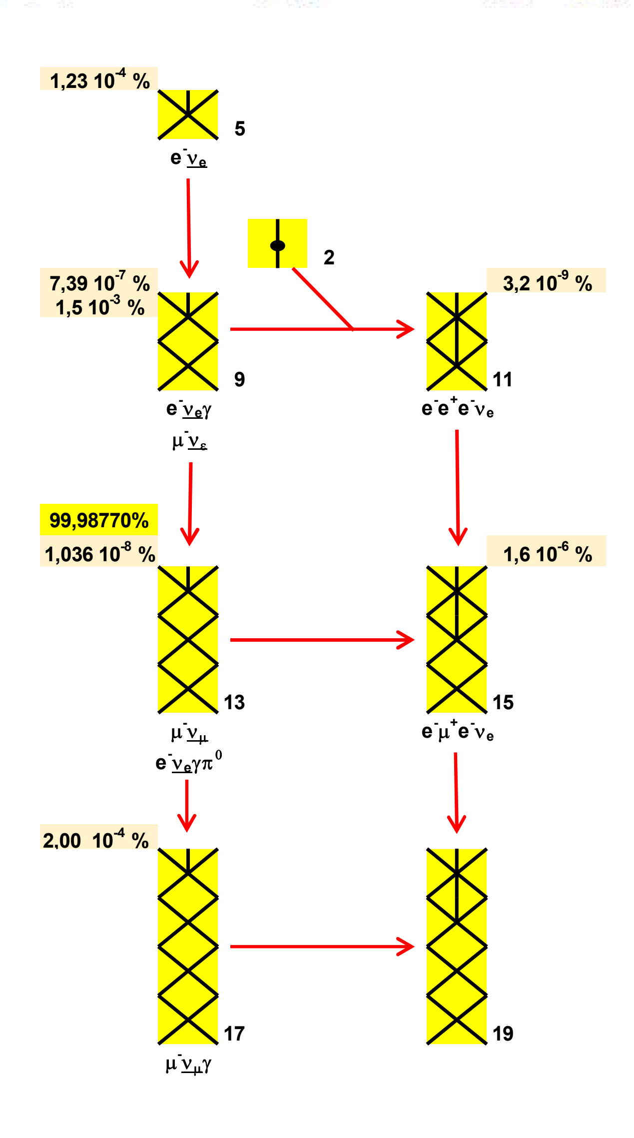
0
2
2
1,7 10-6 %
6,46 10-8 %
4
4
6
8
γ
νeνe
e-e+
4
1,174%
< 3,2 10-10 %
< 3,8 10-10 %
98,823%
1,9 10-7 %
3,34 10-5 %
8
8
10
12
2γ
νeγνe
e-γe+
e-μ+
e+μ-
e-e+e-e+
4
3,1 10-8 %
1, 6 10-6 %
12
12
14
16
3γ
νμνμ
4
2 10-8 %
3,6 10-10 %
16
16
18
20
4γ
e-μ+μ-e+
4
2,1 10-6 %
20
20
22
24
ντντ


$\pi^{\pm}$

Mass $m = 139.57039 \pm 0.00018$ MeV (S = 1.8)
Mean life $\tau = (2.6033 \pm 0.0005) \times 10^{-8}$ s (S = 1.2)
$c\tau = 7.8045$ m

π^- modes are charge conjugates of the modes below.

π^+ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\mu^+ \nu_\mu$	(99.98770 ± 0.00004) %		30
$\mu^+ \nu_\mu \gamma$	$(2.00 \pm 0.25) \times 10^{-4}$		30
$e^+ \nu_e$	$(1.230 \pm 0.004) \times 10^{-4}$		70
$e^+ \nu_e \gamma$	$(7.39 \pm 0.05) \times 10^{-7}$		70
$e^+ \nu_e \pi^0$	$(1.036 \pm 0.006) \times 10^{-8}$		4
$e^+ \nu_e e^+ e^-$	$(3.2 \pm 0.5) \times 10^{-9}$		70
$\mu^+ \nu_\mu \nu \overline{\nu}$	$< 9 \times 10^{-6}$	90%	30
$e^+ \nu_e \nu \overline{\nu}$	$< 1.6 \times 10^{-7}$	90%	70
Lepton Family number (*LF*) or Lepton number (*L*) violating modes			
$\mu^+ \overline{\nu}_e$	$< 1.5 \times 10^{-3}$	90%	30
$\mu^+ \nu_e$	$< 8.0 \times 10^{-3}$	90%	30
$\mu^- e^+ e^+ \nu$	$< 1.6 \times 10^{-6}$	90%	30



10 Los mesones Ka

$K^{\pm}$

Mass $m = 493.677 \pm 0.016$ MeV
Mean life $\tau = (1.2380 \pm 0.0020) \times 10^{-8}$ s
$c\tau = 3.711$ m

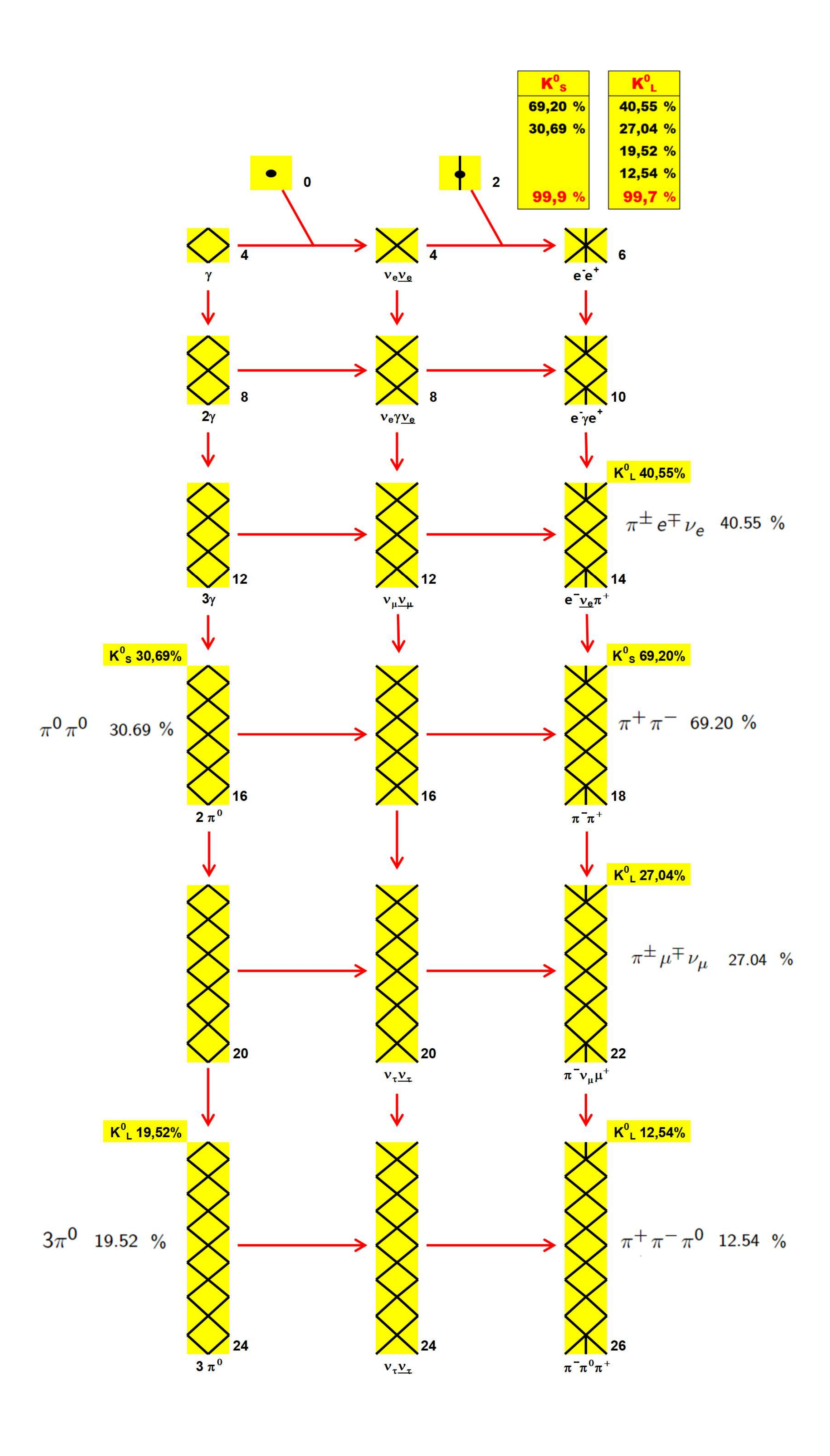
K^+ DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Leptonic and semileptonic modes				
$e^+\nu_e$		$(1.582 \pm 0.007) \times 10^{-5}$		247
$\mu^+\nu_\mu$		(63.56 ± 0.11) %	S=1.2	236
$\pi^0 e^+\nu_e$ Called K^+_{e3}.		(5.07 ± 0.04) %	S=2.1	228
$\pi^0\mu^+\nu_\mu$ Called $K^+_{\mu3}$.		(3.352 ± 0.033) %	S=1.9	215
$\pi^0\pi^0 e^+\nu_e$		$(2.55 \pm 0.04) \times 10^{-5}$	S=1.1	206
$\pi^+\pi^- e^+\nu_e$		$(4.247 \pm 0.024) \times 10^{-5}$		203
$\pi^+\pi^-\mu^+\nu_\mu$		$(1.4 \pm 0.9) \times 10^{-5}$		151
$\pi^0\pi^0\pi^0 e^+\nu_e$		$< 3.5 \times 10^{-6}$	CL=90%	135
Hadronic modes				
$\pi^+\pi^0$		(20.67 ± 0.08) %	S=1.2	205
$\pi^+\pi^0\pi^0$		(1.760 ± 0.023) %	S=1.1	133
$\pi^+\pi^+\pi^-$		(5.583 ± 0.024) %		125
Leptonic and semileptonic modes with photons				
$\mu^+\nu_\mu\gamma$	[r,s]	$(6.2 \pm 0.8) \times 10^{-3}$		236
$\mu^+\nu_\mu\gamma(\text{SD}^+)$	[a,t]	$(1.33 \pm 0.22) \times 10^{-5}$		–
$\mu^+\nu_\mu\gamma(\text{SD}^+\text{INT})$	[a,t]	$< 2.7 \times 10^{-5}$	CL=90%	–
$\mu^+\nu_\mu\gamma(\text{SD}^- + \text{SD}^-\text{INT})$	[a,t]	$< 2.6 \times 10^{-4}$	CL=90%	–
$e^+\nu_e\gamma$		$(9.4 \pm 0.4) \times 10^{-6}$		247
$\pi^0 e^+\nu_e\gamma$	[r,s]	$(2.66 \pm 0.09) \times 10^{-4}$		228
$\pi^0 e^+\nu_e\gamma(\text{SD})$	[a,t]	$< 5.3 \times 10^{-5}$	CL=90%	228
$\pi^0\mu^+\nu_\mu\gamma$	[r,s]	$(1.25 \pm 0.25) \times 10^{-5}$		215
$\pi^0\pi^0 e^+\nu_e\gamma$		$< 5 \times 10^{-6}$	CL=90%	206
Hadronic modes with photons or $\ell\bar{\ell}$ pairs				
$\pi^+\pi^0\gamma(\text{INT})$		$(-4.2 \pm 0.9) \times 10^{-6}$		–
$\pi^+\pi^0\gamma(\text{DE})$	[r,u]	$(6.0 \pm 0.4) \times 10^{-6}$		205
$\pi^+\pi^0 e^+e^-$		$(4.24 \pm 0.14) \times 10^{-6}$		205
$\pi^+\pi^0\pi^0\gamma$	[r,s]	$(7.6\ ^{+6.0}_{-3.0}) \times 10^{-6}$		133
$\pi^+\pi^+\pi^-\gamma$	[r,s]	$(7.1 \pm 0.5) \times 10^{-6}$		125
$\pi^+\gamma\gamma$	[r]	$(1.01 \pm 0.06) \times 10^{-6}$		227
$\pi^+3\gamma$	[r]	$< 1.0 \times 10^{-4}$	CL=90%	227
$\pi^+e^+e^-\gamma$		$(1.19 \pm 0.13) \times 10^{-8}$		227

Leptonic modes with $\ell\overline{\ell}$ pairs

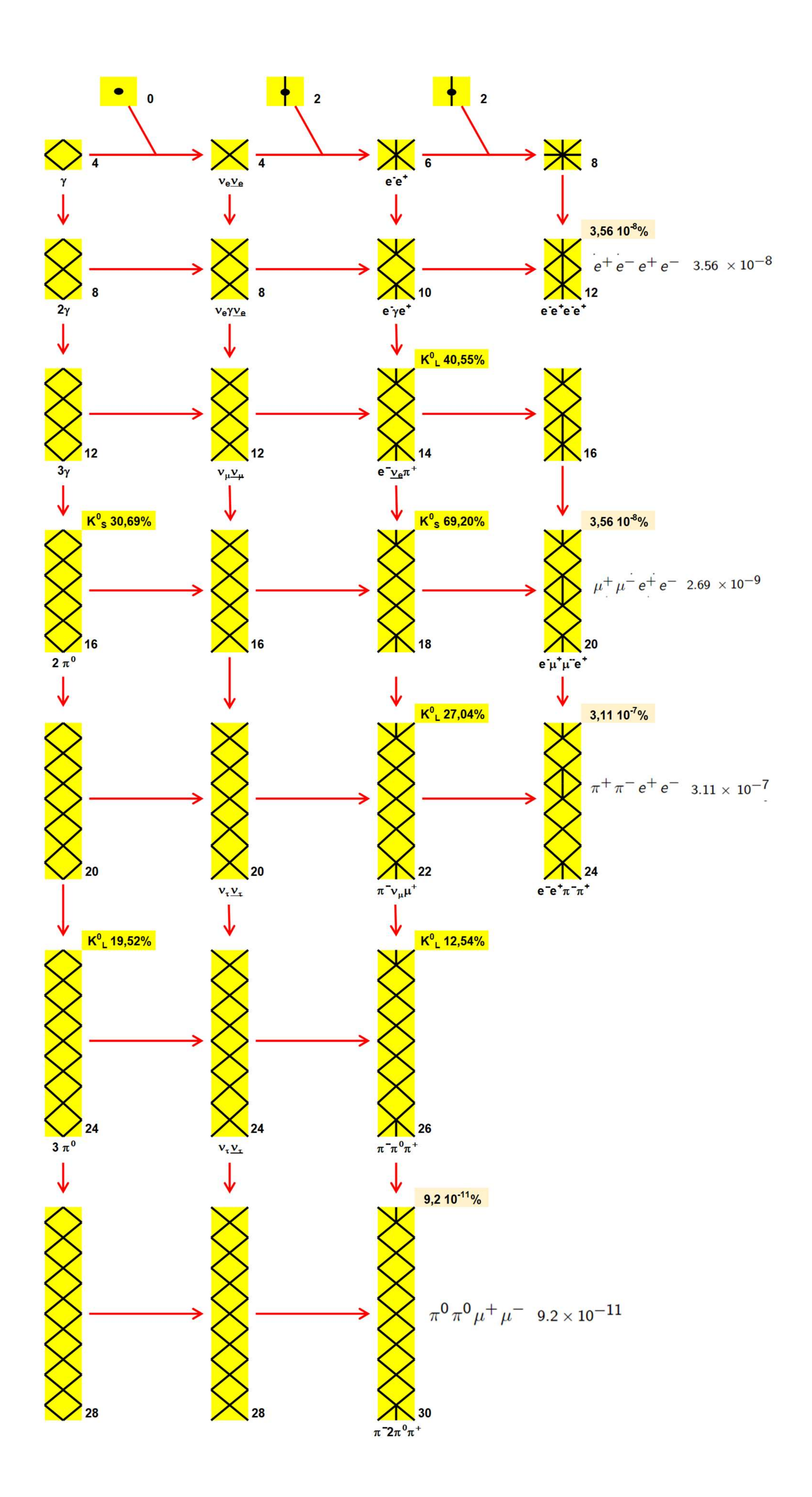
$e^+ \nu_e \nu \overline{\nu}$		<	6		$\times 10^{-5}$	CL=90%	247
$\mu^+ \nu_\mu \nu \overline{\nu}$		<	1.0		$\times 10^{-6}$	CL=90%	236
$e^+ \nu_e e^+ e^-$		(	2.48	±0.20	) $\times 10^{-8}$		247
$\mu^+ \nu_\mu e^+ e^-$		(	7.06	±0.31	) $\times 10^{-8}$		236
$e^+ \nu_e \mu^+ \mu^-$		(	1.7	±0.5	) $\times 10^{-8}$		223
$\mu^+ \nu_\mu \mu^+ \mu^-$		<	4.1		$\times 10^{-7}$	CL=90%	185

Lepton family number (*LF*), Lepton number (*L*), $\Delta S = \Delta Q$ (*SQ*) violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes

$\pi^+ \pi^+ e^- \overline{\nu}_e$	*SQ*	<	1.3		$\times 10^{-8}$	CL=90%	203
$\pi^+ \pi^+ \mu^- \overline{\nu}_\mu$	*SQ*	<	3.0		$\times 10^{-6}$	CL=95%	151
$\pi^+ e^+ e^-$	*S1*	(	3.00	±0.09	) $\times 10^{-7}$		227
$\pi^+ \mu^+ \mu^-$	*S1*	(	9.4	±0.6	) $\times 10^{-8}$	S=2.6	172
$\pi^+ \nu \overline{\nu}$	*S1*	(	1.14	$^{+0.40}_{-0.33}$	) $\times 10^{-10}$		227
$\pi^+ \pi^0 \nu \overline{\nu}$	*S1*	<	4.3		$\times 10^{-5}$	CL=90%	205
$\mu^- \nu e^+ e^+$	*LF*	<	2.1		$\times 10^{-8}$	CL=90%	236
$\mu^+ \nu_e$	*LF*	[*d*] <	4		$\times 10^{-3}$	CL=90%	236
$\pi^+ \mu^+ e^-$	*LF*	<	1.3		$\times 10^{-11}$	CL=90%	214
$\pi^+ \mu^- e^+$	*LF*	<	6.6		$\times 10^{-11}$	CL=90%	214
$\pi^- \mu^+ e^+$	*L*	<	4.2		$\times 10^{-11}$	CL=90%	214
$\pi^- e^+ e^+$	*L*	<	2.2		$\times 10^{-10}$	CL=90%	227
$\pi^- \mu^+ \mu^+$	*L*	<	4.2		$\times 10^{-11}$	CL=90%	172
$\mu^+ \overline{\nu}_e$	*L*	[*d*] <	3.3		$\times 10^{-3}$	CL=90%	236
$\pi^0 e^+ \overline{\nu}_e$	*L*	<	3		$\times 10^{-3}$	CL=90%	228
$\pi^+ \gamma$		[*v*] <	2.3		$\times 10^{-9}$	CL=90%	227



K^0_S
69,20 %
30,69 %
99,9 %
K^0_L
40,55 %
27,04 %
19,52 %
12,54 %
99,7 %
0
2
4
γ
4
$\nu_e \underline{\nu_e}$
6
$e^- e^+$
8
2γ
8
$\nu_e \gamma \underline{\nu_e}$
10
$e^- \gamma e^+$
K^0_L 40,55%
$\pi^\pm e^\mp \nu_e$ 40.55 %
12
3γ
12
$\nu_\mu \underline{\nu_\mu}$
14
$e^- \underline{\nu_e} \pi^+$
K^0_S 30,69%
$\pi^0 \pi^0$ 30.69 %
K^0_S 69,20%
$\pi^+ \pi^-$ 69.20 %
16
$2\pi^0$
16
18
$\pi^- \pi^+$
K^0_L 27,04%
$\pi^\pm \mu^\mp \nu_\mu$ 27.04 %
20
20
$\nu_\tau \underline{\nu_\tau}$
22
$\pi^- \nu_\mu \mu^+$
K^0_L 19,52%
$3\pi^0$ 19.52 %
K^0_L 12,54%
$\pi^+ \pi^- \pi^0$ 12.54 %
24
$3\pi^0$
24
$\nu_\tau \underline{\nu_\tau}$
26
$\pi^- \pi^0 \pi^+$



0
2
2
4
γ
4
$\nu_e \underline{\nu_e}$
6
$e^- e^+$
8
8
2γ
8
$\nu_e \gamma \underline{\nu_e}$
10
$e^- \gamma e^+$
3,56 10^{-8}%
$e^+ e^- e^+ e^-$ 3.56×10^{-8}
12
$e^- e^+ e^- e^+$
12
3γ
12
$\nu_\mu \underline{\nu_\mu}$
K^0_L 40,55%
14
$e^- \underline{\nu_e} \pi^+$
16
K^0_S 30,69%
16
$2\pi^0$
16
K^0_S 69,20%
18
3,56 10^{-8}%
$\mu^+ \mu^- e^+ e^-$ 2.69×10^{-9}
20
$e^- \mu^+ \mu^- e^+$
20
20
$\nu_\tau \underline{\nu_\tau}$
K^0_L 27,04%
22
$\pi^- \nu_\mu \mu^+$
3,11 10^{-7}%
$\pi^+ \pi^- e^+ e^-$ 3.11×10^{-7}
24
$e^- e^+ \pi^- \pi^+$
K^0_L 19,52%
24
$3\pi^0$
24
$\nu_\tau \underline{\nu_\tau}$
K^0_L 12,54%
26
$\pi^- \pi^0 \pi^+$
28
28
9,2 10^{-11}%
$\pi^0 \pi^0 \mu^+ \mu^-$ 9.2×10^{-11}
30
$\pi^- 2\pi^0 \pi^+$

K^0 — 50% K_S, 50% K_L

Mass $m = 497.611 \pm 0.013$ MeV

$m_{K^0} - m_{K^\pm} = 3.934 \pm 0.020$ MeV

K^0_S — Mean life $\tau = (0.8954 \pm 0.0004) \times 10^{-10}$ s

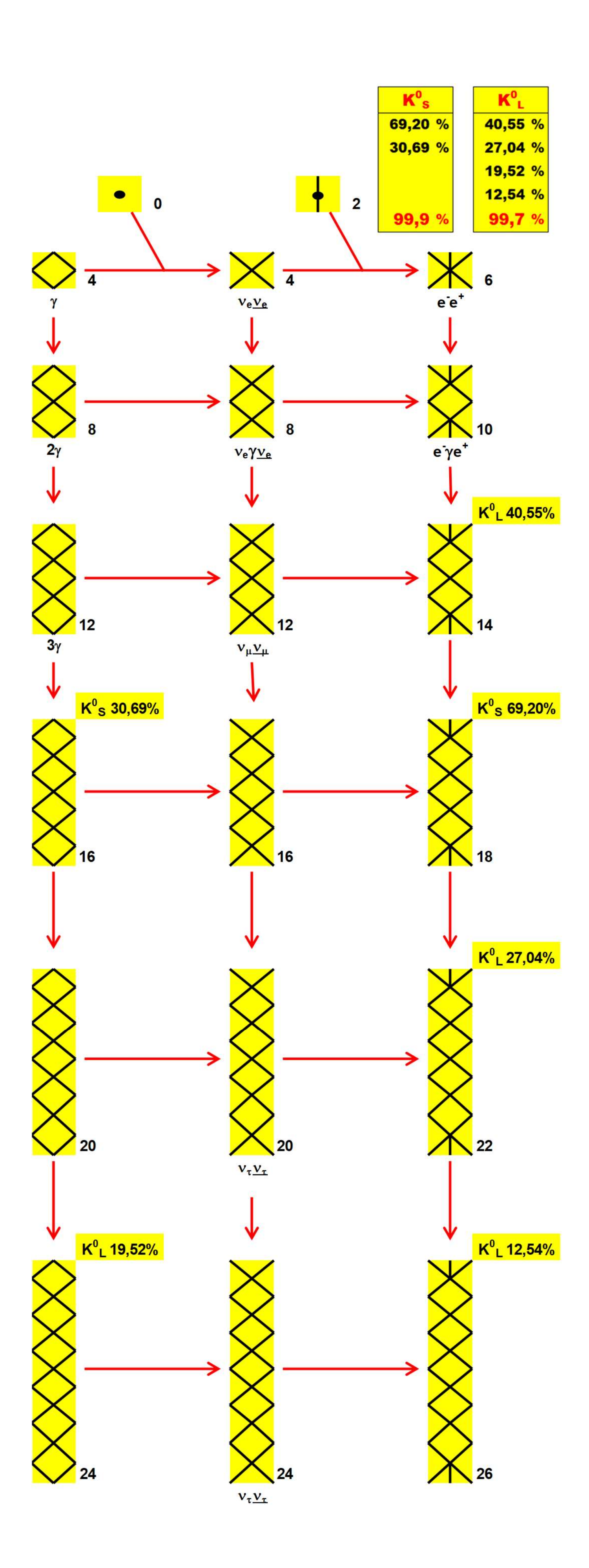
$c\tau = 2.6844$ cm

K^0_S DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Hadronic modes			
$\pi^0\pi^0$	(30.69 ± 0.05) %		209
$\pi^+\pi^-$	(69.20 ± 0.05) %		206
$\pi^+\pi^-\pi^0$	$(3.5\ ^{+1.1}_{-0.9}) \times 10^{-7}$		133
Modes with photons or $\ell\overline{\ell}$ pairs			
$\pi^+\pi^-\gamma$	$(1.79 \pm 0.05) \times 10^{-3}$		206
$\pi^+\pi^- e^+ e^-$	$(4.79 \pm 0.15) \times 10^{-5}$		206
$\pi^0\gamma\gamma$	$(4.9 \pm 1.8) \times 10^{-8}$		230
$\gamma\gamma$	$(2.63 \pm 0.17) \times 10^{-6}$	S=3.1	249
Semileptonic modes			
$\pi^\pm e^\mp \nu_e$	$(7.04 \pm 0.08) \times 10^{-4}$		229
***CP* violating (*CP*) and $\Delta S = 1$ weak neutral current (*S1*) modes**			
$3\pi^0$	$< 2.6 \times 10^{-8}$	CL=90%	139
$\mu^+\mu^-$	$< 2.1 \times 10^{-10}$	CL=90%	225
e^+e^-	$< 9 \times 10^{-9}$	CL=90%	249
$\pi^0 e^+ e^-$	$(3.0\ ^{+1.5}_{-1.2}) \times 10^{-9}$		230
$\pi^0 \mu^+ \mu^-$	$(2.9\ ^{+1.5}_{-1.2}) \times 10^{-9}$		177

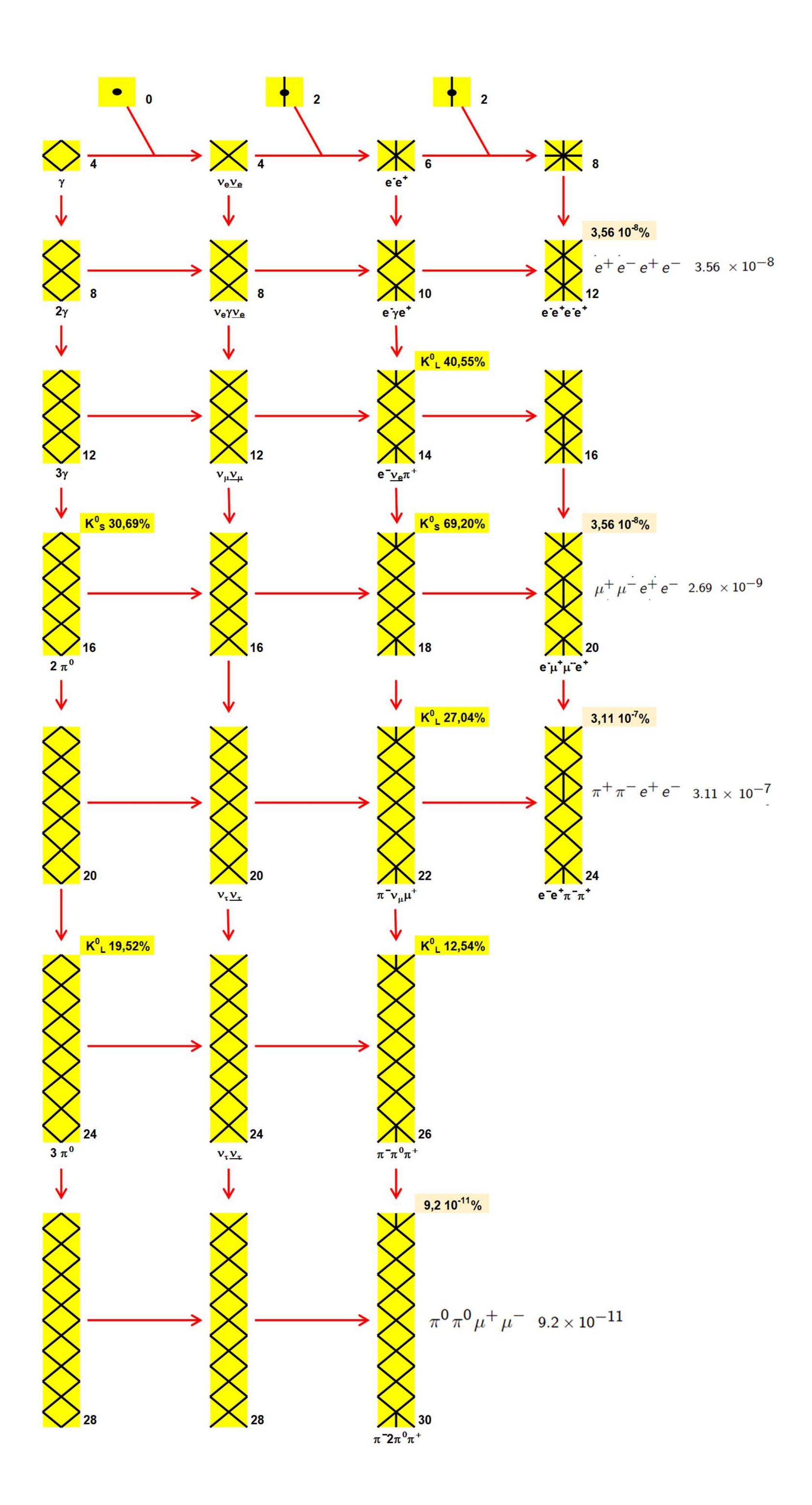
K^0_L Mean life $\tau = (5.116 \pm 0.021) \times 10^{-8}$ s

$c\tau = 15.34$ m

K^0_L DECAY MODES			Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Semileptonic modes					
$\pi^\pm e^\mp \nu_e$		[aa]	(40.55 ± 0.11) %	S=1.7	229
Called K^0_{e3}.					
$\pi^\pm \mu^\mp \nu_\mu$		[aa]	(27.04 ± 0.07) %	S=1.1	216
Called $K^0_{\mu3}$.					
$(\pi\mu\,\text{atom})\nu$			$(1.05 \pm 0.11) \times 10^{-7}$		188
$\pi^0\pi^\pm e^\mp \nu$		[aa]	$(5.20 \pm 0.11) \times 10^{-5}$		207
$\pi^\pm e^\mp \nu e^+ e^-$		[aa]	$(1.26 \pm 0.04) \times 10^{-5}$		229
Hadronic modes, including Charge conjugation×Parity Violating (*CPV*) modes					
$3\pi^0$			(19.52 ± 0.12) %	S=1.6	139
$\pi^+\pi^-\pi^0$			(12.54 ± 0.05) %		133
$\pi^+\pi^-$	*CPV*	[cc]	$(1.967 \pm 0.010) \times 10^{-3}$	S=1.5	206
$\pi^0\pi^0$	*CPV*		$(8.64 \pm 0.06) \times 10^{-4}$	S=1.8	209
Semileptonic modes with photons					
$\pi^\pm e^\mp \nu_e \gamma$		[x,aa,dd]	$(3.79 \pm 0.06) \times 10^{-3}$		229
$\pi^\pm \mu^\mp \nu_\mu \gamma$			$(5.65 \pm 0.23) \times 10^{-4}$		216
Hadronic modes with photons or $\ell\overline{\ell}$ pairs					
$\pi^0\pi^0\gamma$			$< 2.43 \times 10^{-7}$	CL=90%	209
$\pi^+\pi^-\gamma$		[x,dd]	$(4.15 \pm 0.15) \times 10^{-5}$	S=2.8	206
$\pi^+\pi^-\gamma(\text{DE})$			$(2.84 \pm 0.11) \times 10^{-5}$	S=2.0	206
$\pi^0 2\gamma$		[dd]	$(1.273 \pm 0.033) \times 10^{-6}$		230
$\pi^0\gamma e^+ e^-$			$(1.62 \pm 0.17) \times 10^{-8}$		230
Other modes with photons or $\ell\overline{\ell}$ pairs					
2γ			$(5.47 \pm 0.04) \times 10^{-4}$	S=1.1	249
3γ			$< 7.4 \times 10^{-8}$	CL=90%	249
$e^+e^-\gamma$			$(9.4 \pm 0.4) \times 10^{-6}$	S=2.0	249
$\mu^+\mu^-\gamma$			$(3.59 \pm 0.11) \times 10^{-7}$	S=1.3	225
$e^+e^-\gamma\gamma$		[dd]	$(5.95 \pm 0.33) \times 10^{-7}$		249
$\mu^+\mu^-\gamma\gamma$		[dd]	$(1.0\ ^{+0.8}_{-0.6}) \times 10^{-8}$		225
Charge conjugation × Parity (*CP*) or Lepton Family number (*LF*) violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes					
$\mu^+\mu^-$	*S1*		$(6.84 \pm 0.11) \times 10^{-9}$		225
e^+e^-	*S1*		$(9\ ^{+6}_{-4}) \times 10^{-12}$		249
$\pi^+\pi^- e^+ e^-$	*S1*	[dd]	$(3.11 \pm 0.19) \times 10^{-7}$		206
$\pi^0\pi^0 e^+ e^-$	*S1*		$< 6.6 \times 10^{-9}$	CL=90%	209
$\pi^0\pi^0\mu^+\mu^-$	*S1*		$< 9.2 \times 10^{-11}$	CL=90%	57
$\mu^+\mu^- e^+ e^-$	*S1*		$(2.69 \pm 0.27) \times 10^{-9}$		225
$e^+e^- e^+ e^-$	*S1*		$(3.56 \pm 0.21) \times 10^{-8}$		249
$\pi^0\mu^+\mu^-$	*CP,S1*	[ee]	$< 3.8 \times 10^{-10}$	CL=90%	177
$\pi^0 e^+ e^-$	*CP,S1*	[ee]	$< 2.8 \times 10^{-10}$	CL=90%	230
$\pi^0\nu\overline{\nu}$	*CP,S1*	[ff]	$< 3.0 \times 10^{-9}$	CL=90%	230
$\pi^0\pi^0\nu\overline{\nu}$	*S1*		$< 8.1 \times 10^{-7}$	CL=90%	209
$e^\pm\mu^\mp$	*LF*	[aa]	$< 4.7 \times 10^{-12}$	CL=90%	238
$e^\pm e^\pm \mu^\mp \mu^\mp$	*LF*	[aa]	$< 4.12 \times 10^{-11}$	CL=90%	225
$\pi^0\mu^\pm e^\mp$	*LF*	[aa]	$< 7.6 \times 10^{-11}$	CL=90%	217
$\pi^0\pi^0\mu^\pm e^\mp$	*LF*		$< 1.7 \times 10^{-10}$	CL=90%	159
Lorentz invariance violating modes					
$\pi^0\gamma$			$< 1.7 \times 10^{-7}$	CL=90%	230



K0S
69,20 %
30,69 %
99,9 %
K0L
40,55 %
27,04 %
19,52 %
12,54 %
99,7 %
0
2
4
γ
4
νeνe
6
e-e+
8
2γ
8
νeγνe
10
e-γe+
K0L 40,55%
12
3γ
12
νμνμ
14
K0S 30,69%
K0S 69,20%
16
16
18
K0L 27,04%
20
20
ντντ
22
K0L 19,52%
K0L 12,54%
24
24
ντντ
26

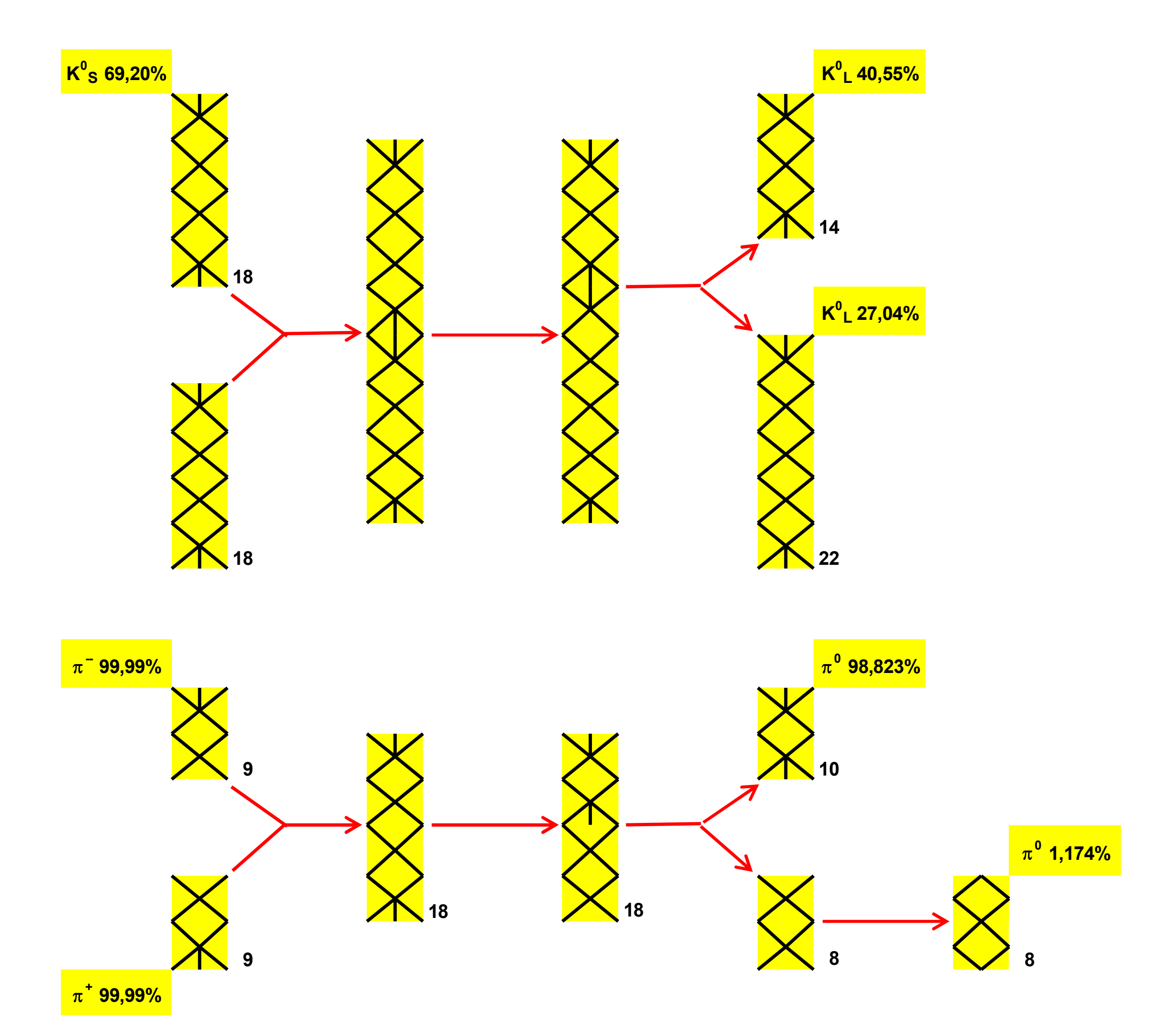


0
2
2
4
4
6
8
γ
$\nu_e \underline{\nu_e}$
$e^- e^+$
3,56 10^{-8}%
$e^+ e^- e^+ e^-$ 3.56×10^{-8}
8
8
10
12
2γ
$\nu_e \gamma \underline{\nu_e}$
$e^- \gamma e^+$
$e^- e^+ e^- e^+$
K^0_L 40,55%
12
12
14
16
3γ
$\nu_\mu \underline{\nu_\mu}$
$e^- \underline{\nu_e} \pi^+$
K^0_S 30,69%
K^0_S 69,20%
3,56 10^{-8}%
$\mu^+ \mu^- e^+ e^-$ 2.69×10^{-9}
16
16
18
20
2 π^0
$e^- \mu^+ \mu^- e^+$
K^0_L 27,04%
3,11 10^{-7}%
$\pi^+ \pi^- e^+ e^-$ 3.11×10^{-7}
20
20
22
24
$\nu_\tau \underline{\nu_\tau}$
$\pi^- \nu_\mu \mu^+$
$e^- e^+ \pi^- \pi^+$
K^0_L 19,52%
K^0_L 12,54%
24
24
26
3 π^0
$\nu_\tau \underline{\nu_\tau}$
$\pi^- \pi^0 \pi^+$
9,2 10^{-11}%
$\pi^0 \pi^0 \mu^+ \mu^-$ 9.2×10^{-11}
28
28
30
$\pi^- 2\pi^0 \pi^+$

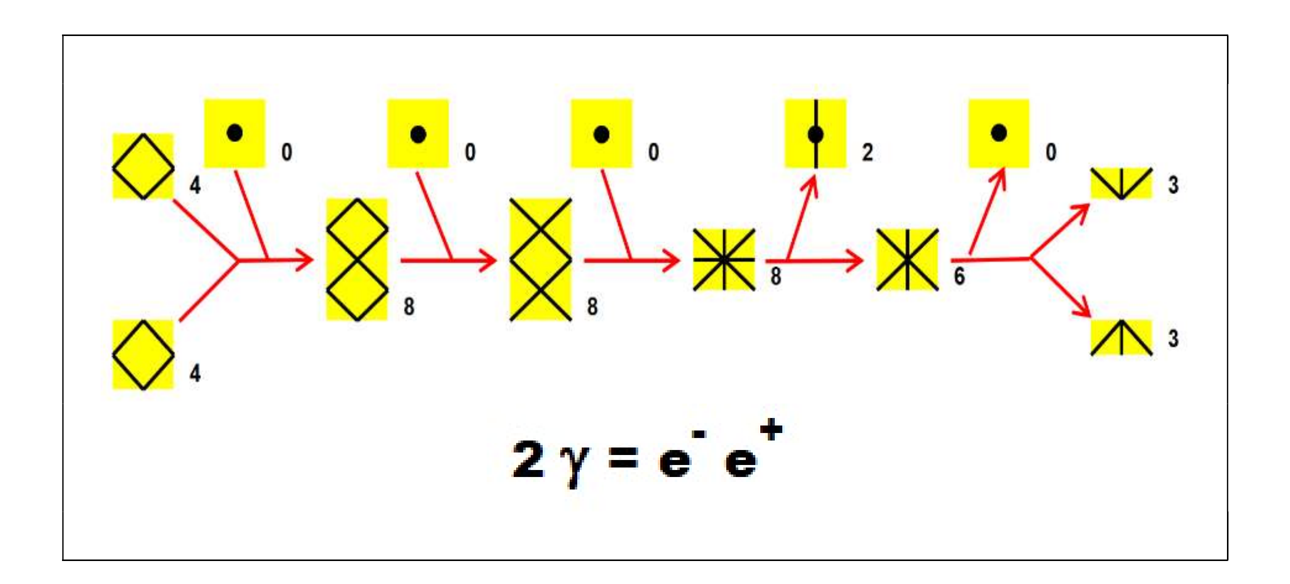
Dismutación o Desproporción de K^0 y π^0

2A = A’ + A”

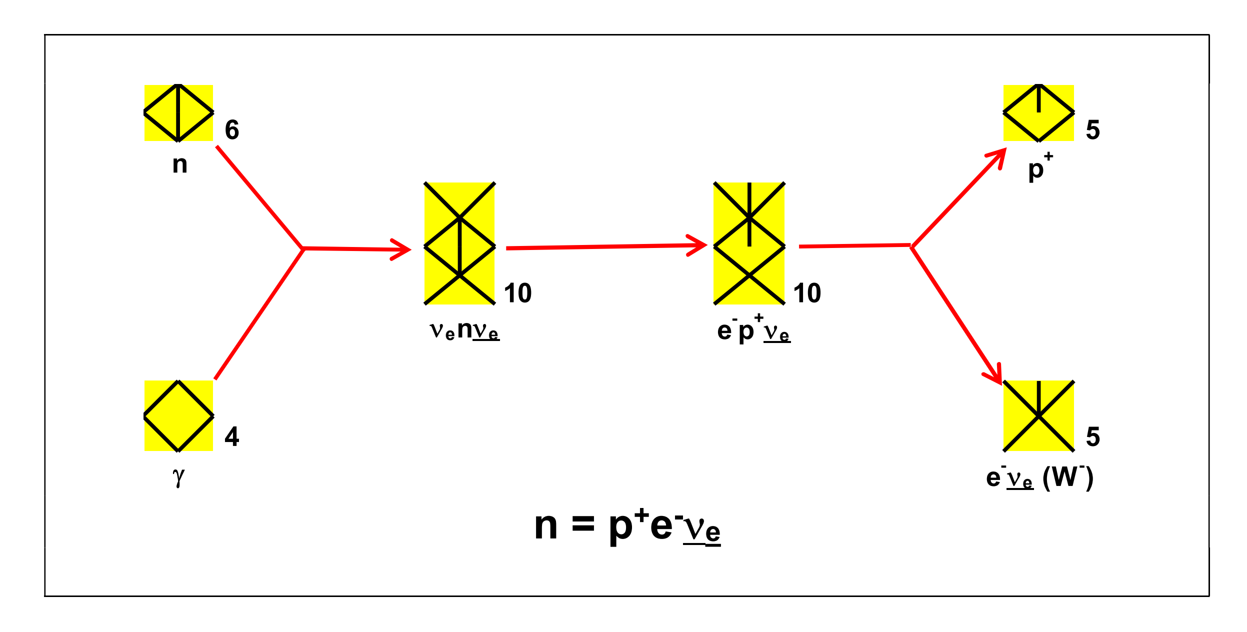
A +<u>A</u> = A’ + A”

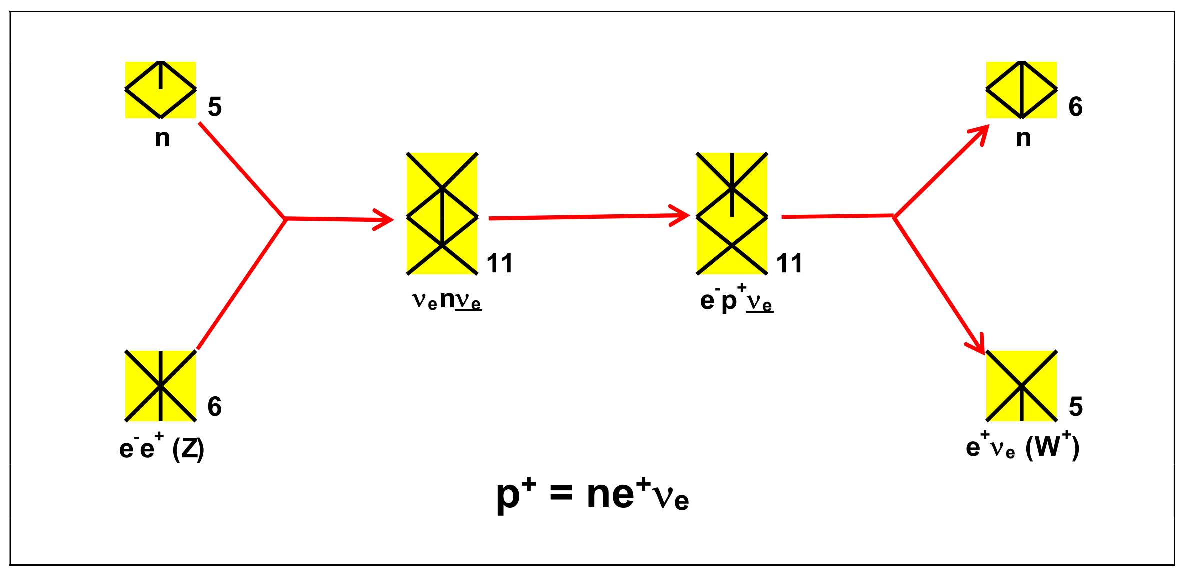


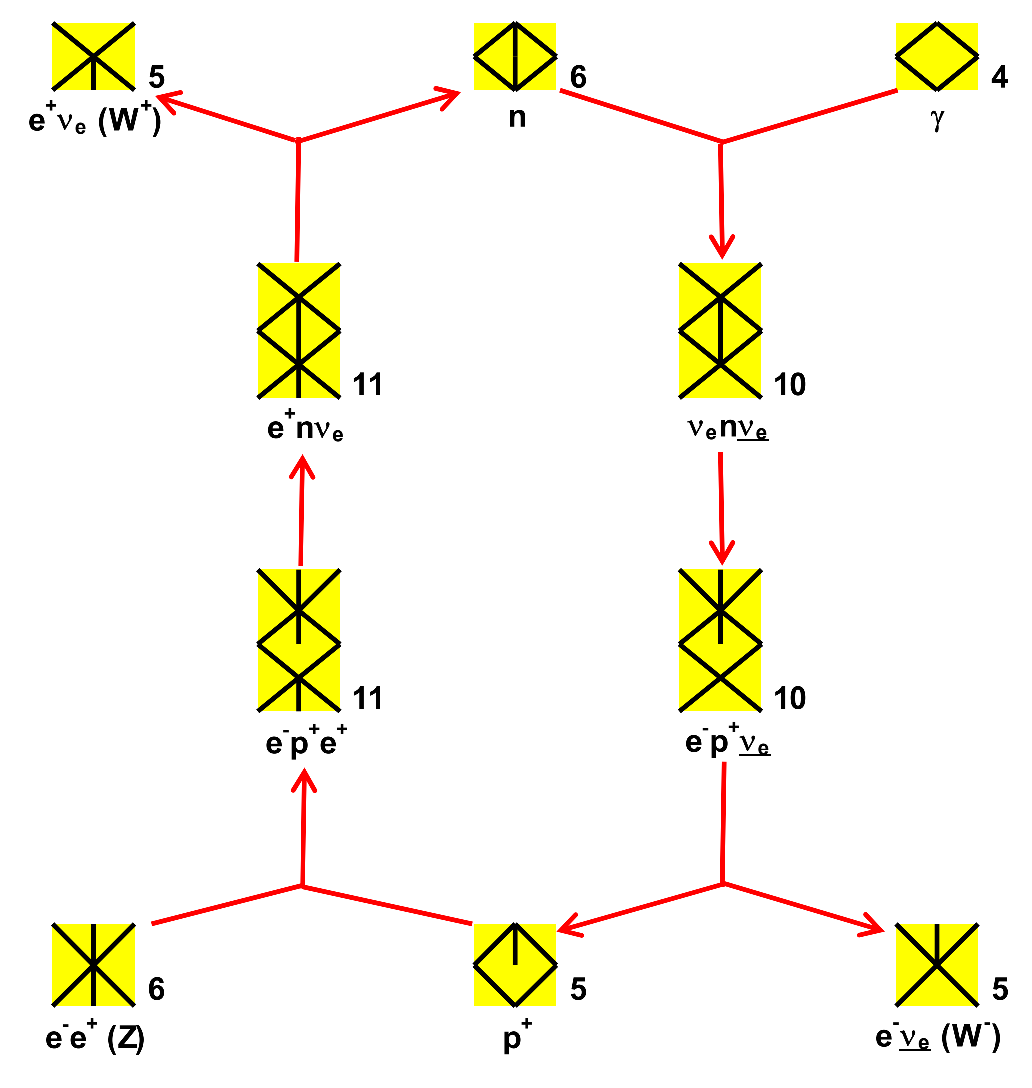
11 Conversión de fotones en electrones

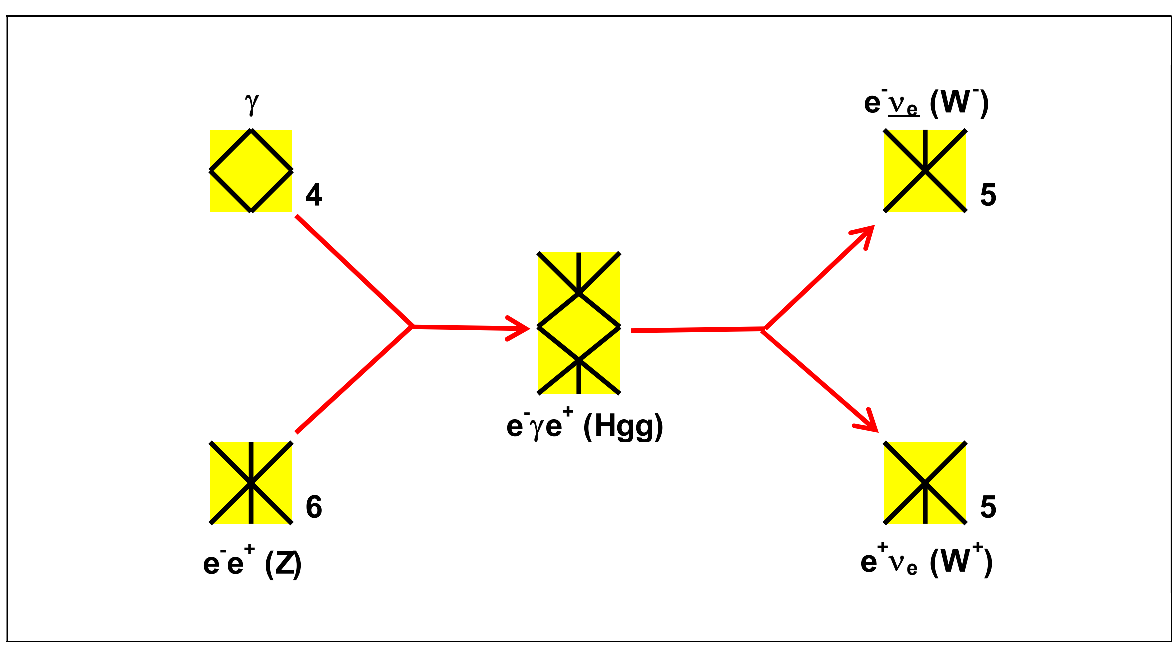


12 Desintegración beta de n y p





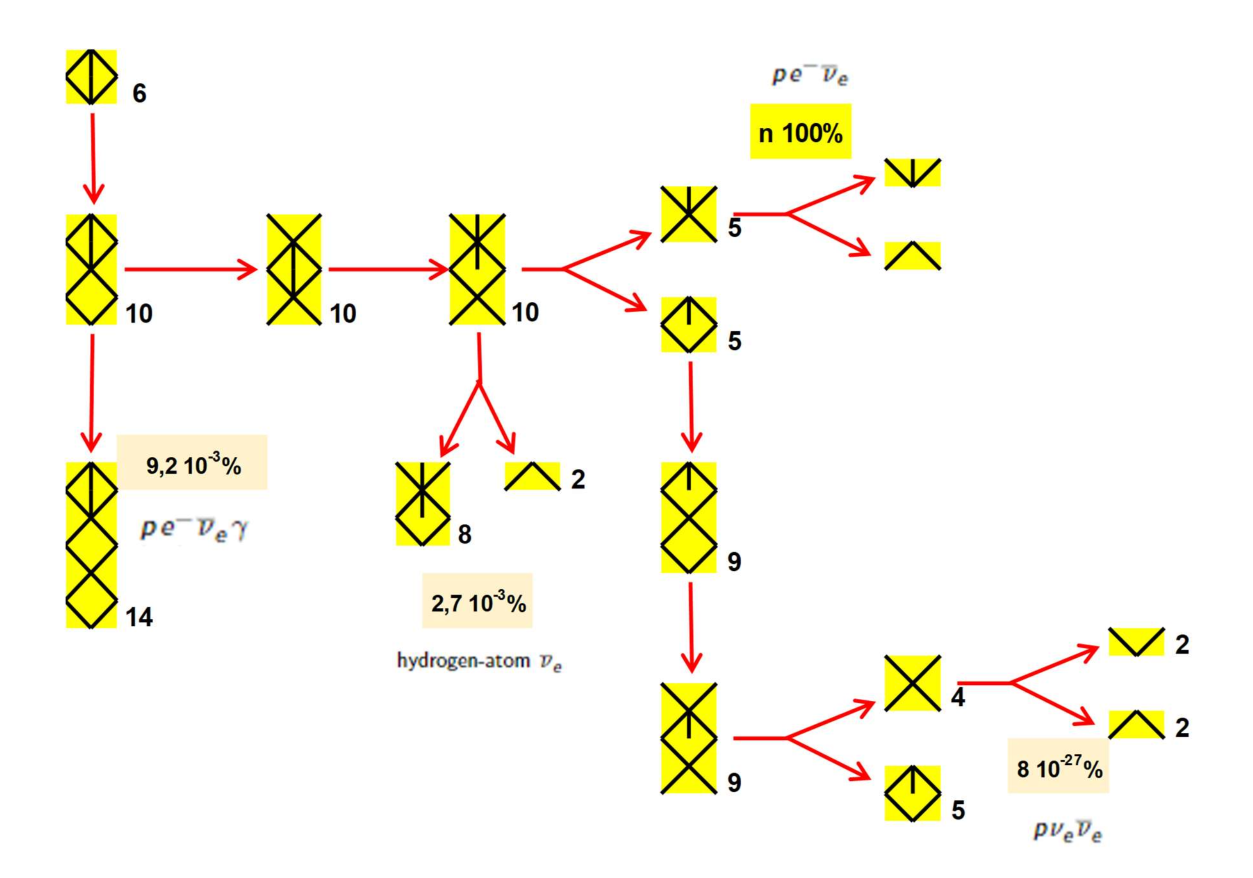

5
$e^+\nu_e$ (W^+)
6
n
4
γ
11
$e^+n\nu_e$
10
$\nu_e n \underline{\nu_e}$
11
$e^-p^+e^+$
10
$e^-p^+\underline{\nu_e}$
6
e^-e^+ (Z)
5
p^+
5
$e^-\underline{\nu_e}$ (W^-)


γ
4
$e^-\underline{\nu_e}$ (W^-)
5
$e^-\gamma e^+$ (Hgg)
6
e^-e^+ (Z)
5
$e^+\nu_e$ (W^+)

n

Mass $m = 1.0086649160 \pm 0.0000000005$ u
Mass $m = 939.5654205 \pm 0.0000005$ MeV [a]
$(m_n - m_{\bar{n}})/ m_n = (9 \pm 6) \times 10^{-5}$
$m_n - m_p = 1.2933324 \pm 0.0000005$ MeV
$= 0.00138844919(45)$ u
Mean life $\tau = 878.4 \pm 0.5$ s (S = 1.8)
$c\tau = 2.6335 \times 10^8$ km

n DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$p e^- \overline{\nu}_e$		100 %		1
$p e^- \overline{\nu}_e \gamma$	[f]	$(9.2 \pm 0.7) \times 10^{-3}$		1
hydrogen-atom $\overline{\nu}_e$		$< 2.7 \times 10^{-3}$	95%	1.19
Charge conservation (Q) violating mode				
$p \nu_e \overline{\nu}_e$	Q	$< 8 \times 10^{-27}$	68%	1



13 Bariones Lambda, Sigma y Xi, neutros

Λ

Mass $m = 1115.683 \pm 0.006$ MeV
$(m_\Lambda - m_{\overline{\Lambda}}) \,/\, m_\Lambda = (-0.1 \pm 1.1) \times 10^{-5}$
Mean life $\tau = (2.632 \pm 0.020) \times 10^{-10}$ s
$c\tau = 7.89$ cm

Λ DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$p\pi^-$		(63.9 ± 0.5) %		101
$n\pi^0$		(35.8 ± 0.5) %		104
$n\gamma$		$(1.75 \pm 0.15) \times 10^{-3}$		162
$p\pi^-\gamma$	[o]	$(8.4 \pm 1.4) \times 10^{-4}$		101
$pe^-\overline{\nu}_e$		$(8.32 \pm 0.14) \times 10^{-4}$		163
$p\mu^-\overline{\nu}_\mu$		$(1.57 \pm 0.35) \times 10^{-4}$		131
Lepton (L) and/or Baryon (B) number violating decay modes				
π^+e^-	L,B	$< 6 \times 10^{-7}$	90%	549
$\pi^+\mu^-$	L,B	$< 6 \times 10^{-7}$	90%	544
π^-e^+	L,B	$< 4 \times 10^{-7}$	90%	549
$\pi^-\mu^+$	L,B	$< 6 \times 10^{-7}$	90%	544
K^+e^-	L,B	$< 2 \times 10^{-6}$	90%	449
$K^+\mu^-$	L,B	$< 3 \times 10^{-6}$	90%	441
K^-e^+	L,B	$< 2 \times 10^{-6}$	90%	449
$K^-\mu^+$	L,B	$< 3 \times 10^{-6}$	90%	441
$K^0_S\nu$	L,B	$< 2 \times 10^{-5}$	90%	447
$\overline{p}\pi^+$	B	$< 9 \times 10^{-7}$	90%	101

Σ^0

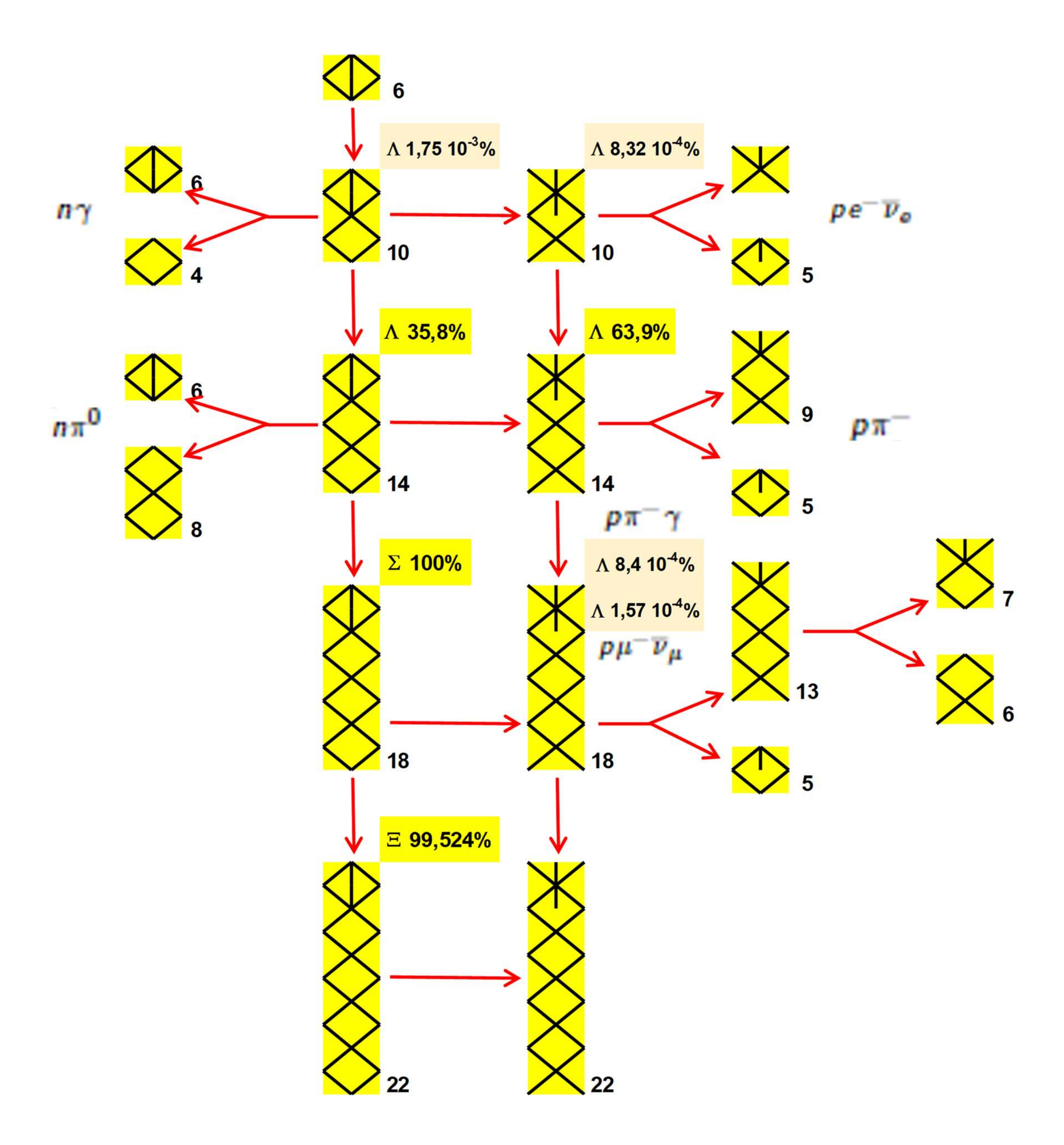
Mass $m = 1192.642 \pm 0.024$ MeV
$m_{\Sigma^-} - m_{\Sigma^0} = 4.807 \pm 0.035$ MeV (S = 1.1)
$m_{\Sigma^0} - m_\Lambda = 76.959 \pm 0.023$ MeV
Mean life $\tau = (7.4 \pm 0.7) \times 10^{-20}$ s
$c\tau = 2.22 \times 10^{-11}$ m

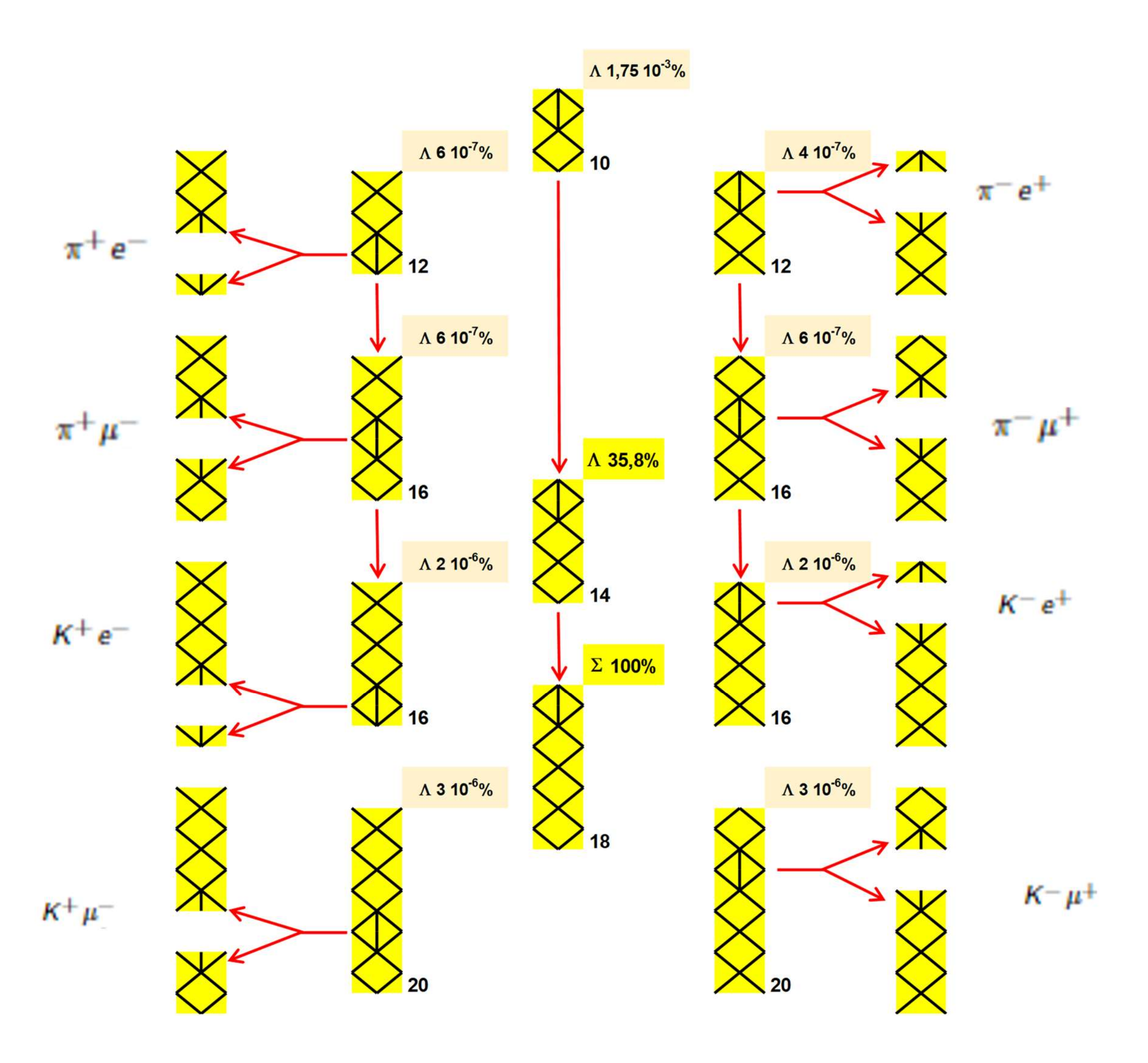
Σ^0 DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\gamma$		100 %		74
$\Lambda\gamma\gamma$		< 3 %	90%	74
Λe^+e^-	[q]	5×10^{-3}		74



Mass $m = 1314.86 \pm 0.20$ MeV
$m_{\Xi^-} - m_{\Xi^0} = 6.85 \pm 0.21$ MeV
Mean life $\tau = (2.90 \pm 0.09) \times 10^{-10}$ s
$c\tau = 8.71$ cm

Ξ^0 DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$\Lambda\pi^0$		(99.524 ± 0.012) %		135
$\Lambda\gamma$		$(1.17 \pm 0.07) \times 10^{-3}$		184
Λe^+e^-		$(7.6 \pm 0.6) \times 10^{-6}$		184
$\Sigma^0\gamma$		$(3.33 \pm 0.10) \times 10^{-3}$		117
$\Sigma^+e^-\overline{\nu}_e$		$(2.52 \pm 0.08) \times 10^{-4}$		120
$\Sigma^+\mu^-\overline{\nu}_\mu$		$(2.33 \pm 0.35) \times 10^{-6}$		64
$\Delta S = \Delta Q$ (SQ) violating modes or $\Delta S = 2$ forbidden ($S2$) modes				
$\Sigma^-e^+\nu_e$	SQ	$< 9 \times 10^{-4}$	90%	112
$\Sigma^-\mu^+\nu_\mu$	SQ	$< 9 \times 10^{-4}$	90%	49
$p\pi^-$	$S2$	$< 8 \times 10^{-6}$	90%	299
$pe^-\overline{\nu}_e$	$S2$	$< 1.3 \times 10^{-3}$		323
$p\mu^-\overline{\nu}_\mu$	$S2$	$< 1.3 \times 10^{-3}$		309


6
Λ 1,75 10-3%
Λ 8,32 10-4%
nγ
6
4
10
10
pe⁻ν̄e
5
Λ 35,8%
Λ 63,9%
6
nπ0
8
14
14
9
pπ⁻
5
pπ⁻γ
Σ 100%
Λ 8,4 10-4%
Λ 1,57 10-4%
pμ⁻ν̄μ
7
13
6
18
18
5
Ξ 99,524%
22
22


Λ 1,75 10-3%
10
Λ 6 10-7%
12
π+ e−
Λ 4 10-7%
12
π− e+
Λ 6 10-7%
16
π+ μ−
Λ 6 10-7%
16
π− μ+
Λ 35,8%
14
Λ 2 10-6%
16
K+ e−
Λ 2 10-6%
16
K− e+
Σ 100%
18
Λ 3 10-6%
20
K+ μ−
Λ 3 10-6%
20
K− μ+

14 Bariones Delta

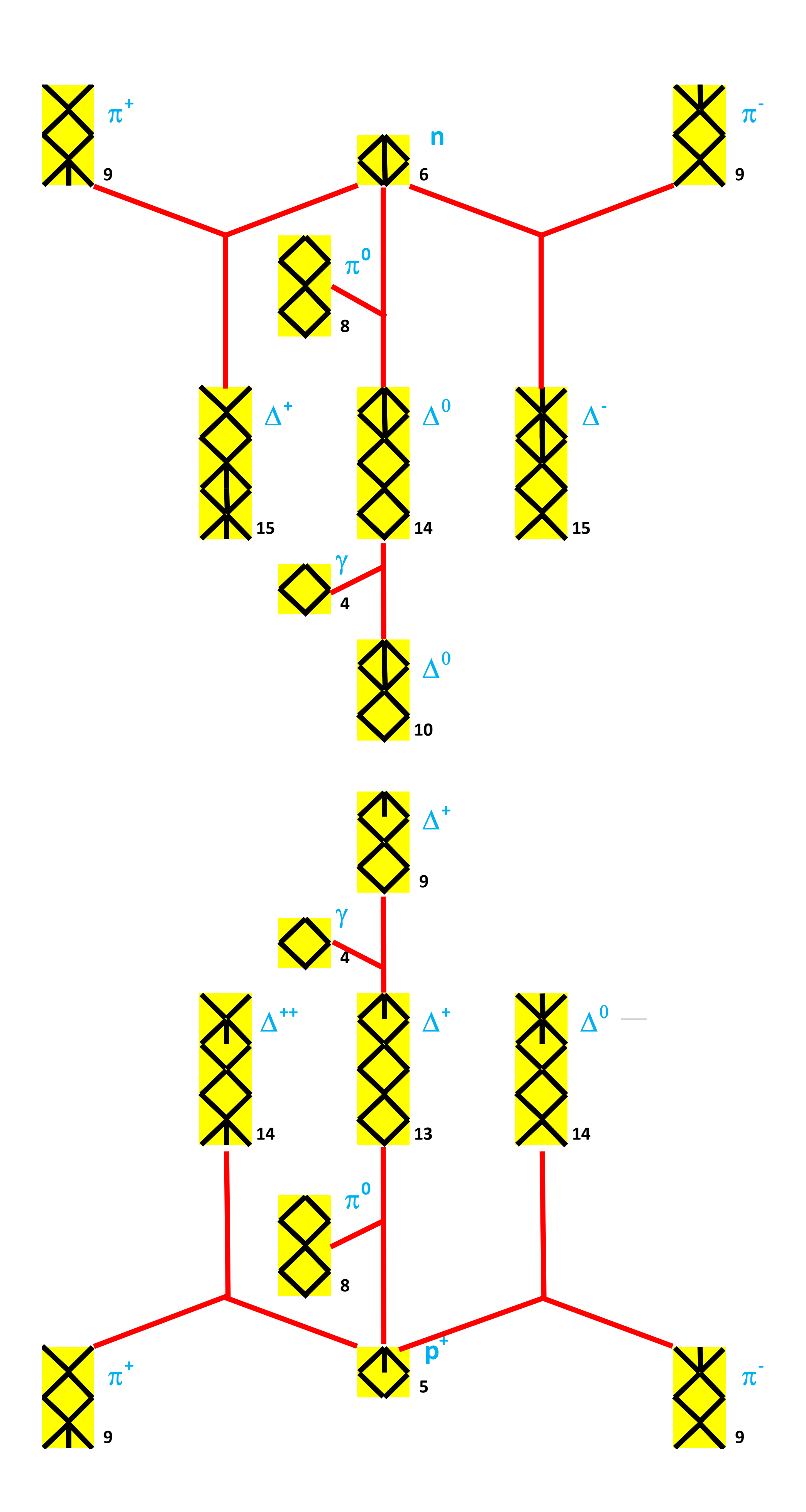
Δ(1232)

Breit-Wigner mass (mixed charges) = 1230 to 1234 (≈ 1232) MeV

Δ(1232) DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$N\pi$	99.4 %	229
$N\gamma$	0.55–0.65 %	259
$p e^+ e^-$	$(4.2 \pm 0.7) \times 10^{-5}$	259

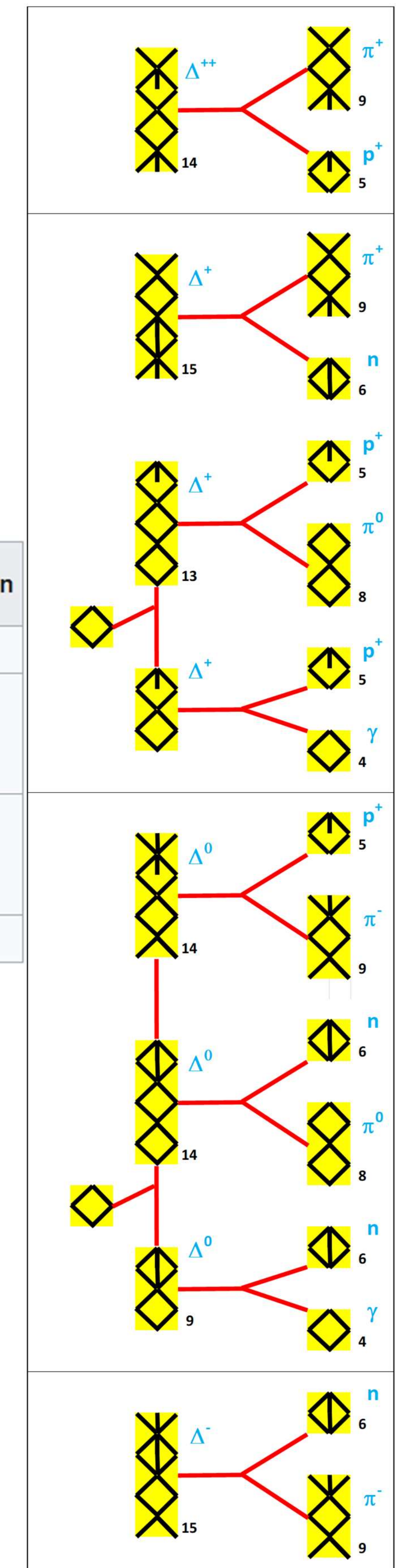
Particule	Quarks	Charge (e)	Désintégration
Δ^{++}	uuu	+2	π^+ + p
Δ^+	uud	+1	π^+ + n π^0 + p γ + p (rare)
Δ^0	udd	0	π^0 + n π^- + p γ + n (rare)
Δ^-	ddd	−1	π^- + n

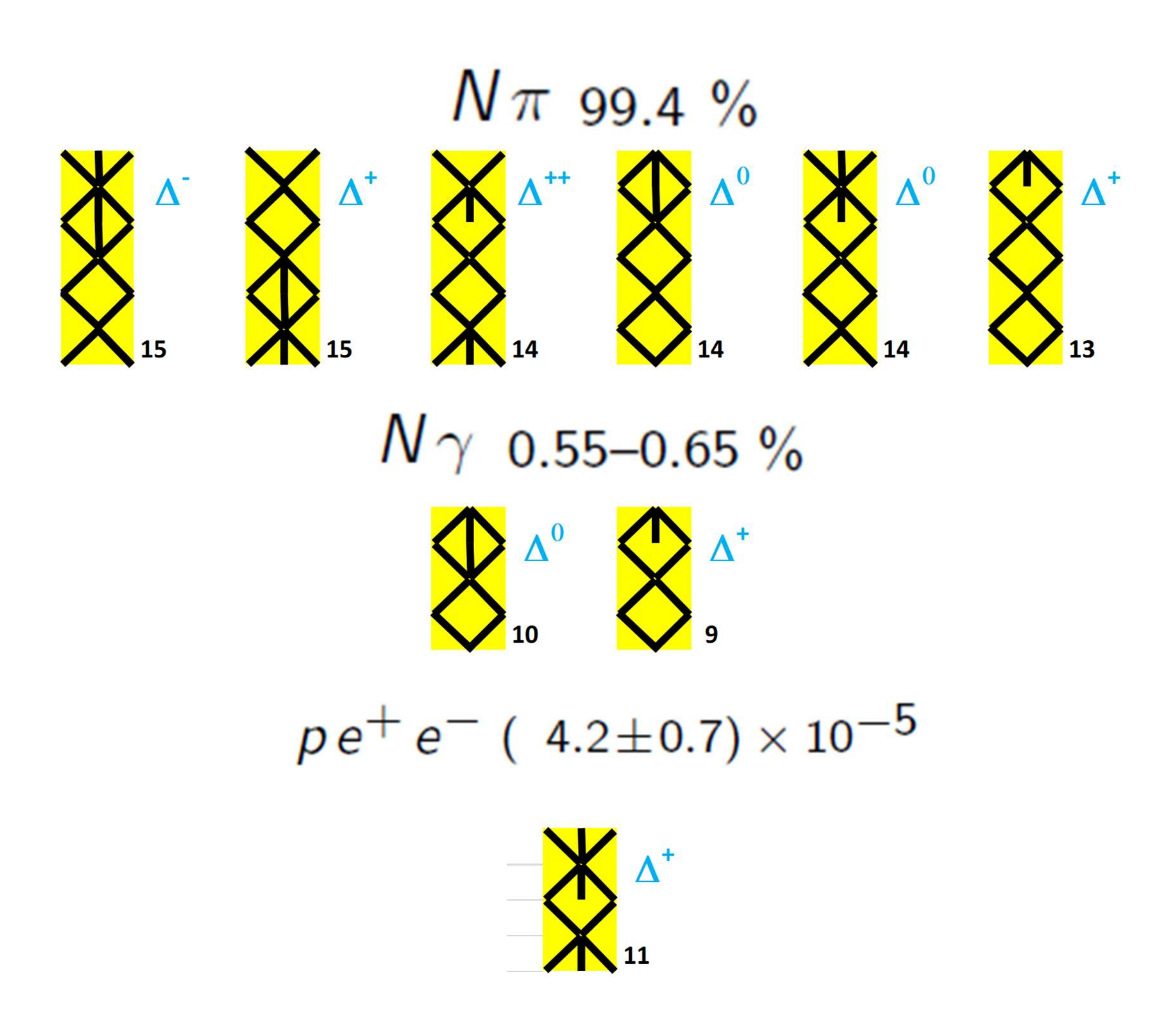
https://fr.wikipedia.org/wiki/Baryon_Delta



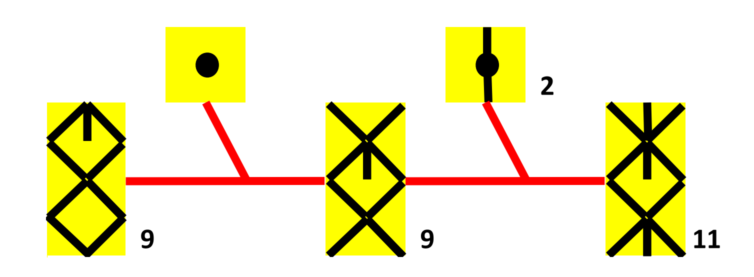
π+
9
n
6
π-
9
π0
8
Δ+
15
Δ0
14
Δ-
15
γ
4
Δ0
10
Δ+
9
γ
4
Δ++
14
Δ+
13
Δ0
14
π0
8
π+
9
p+
5
π-
9

Particule	Désintégration
Δ^{++}	π^+ + p
Δ^+	π^+ + n π^0 + p γ + p (rare)
Δ^0	π^0 + n π^- + p γ + n (rare)
Δ^-	π^- + n





$N\pi$ 99.4 %
Δ^-
15
Δ^+
15
Δ^{++}
14
Δ^0
14
Δ^0
14
Δ^+
13
$N\gamma$ 0.55–0.65 %
Δ^0
10
Δ^+
9
pe^+e^- $(4.2\pm0.7)\times10^{-5}$
Δ^+
11



2
9
9
11

15 El quark top

t

Charge = $\frac{2}{3}$ e

Mass (direct measurements) $m = 172.69 \pm 0.30$ GeV [a,b]

Mass (from cross-section measurements) $m = 162.5^{+2.1}_{-1.5}$ GeV

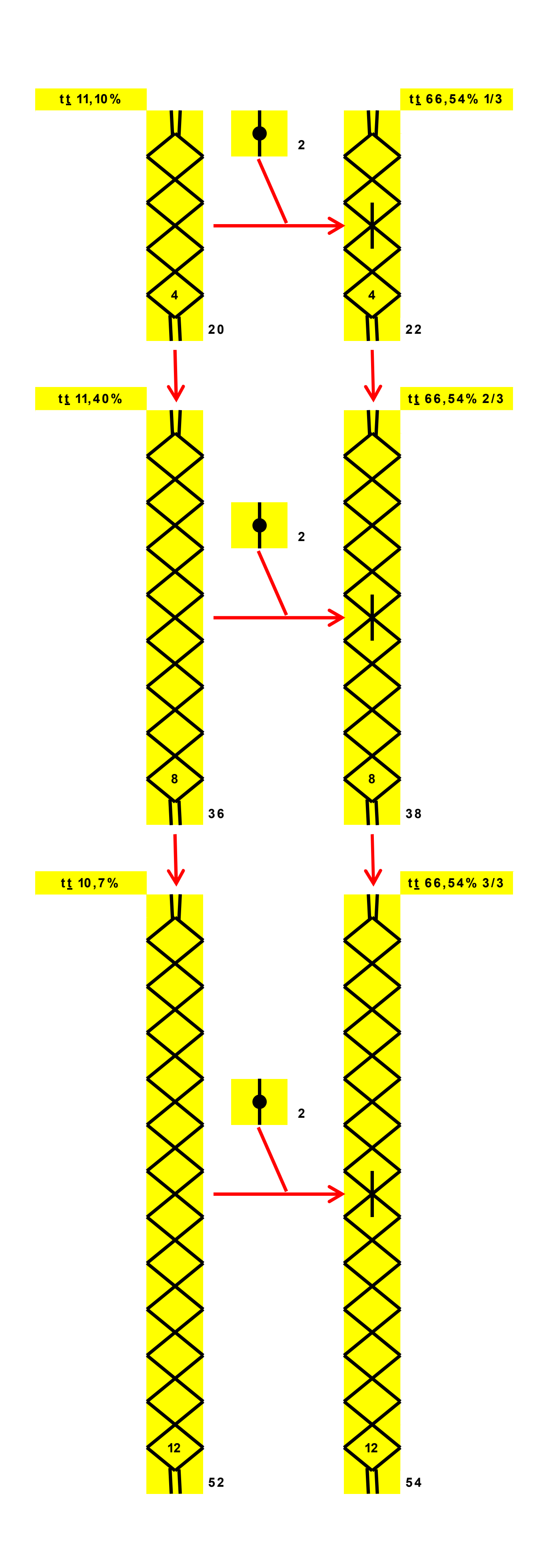
Mass (Pole from cross-section measurements) $m = 172.5 \pm 0.7$ GeV

$m_t - m_{\overline{t}} = -0.15 \pm 0.20$ GeV (S = 1.1)

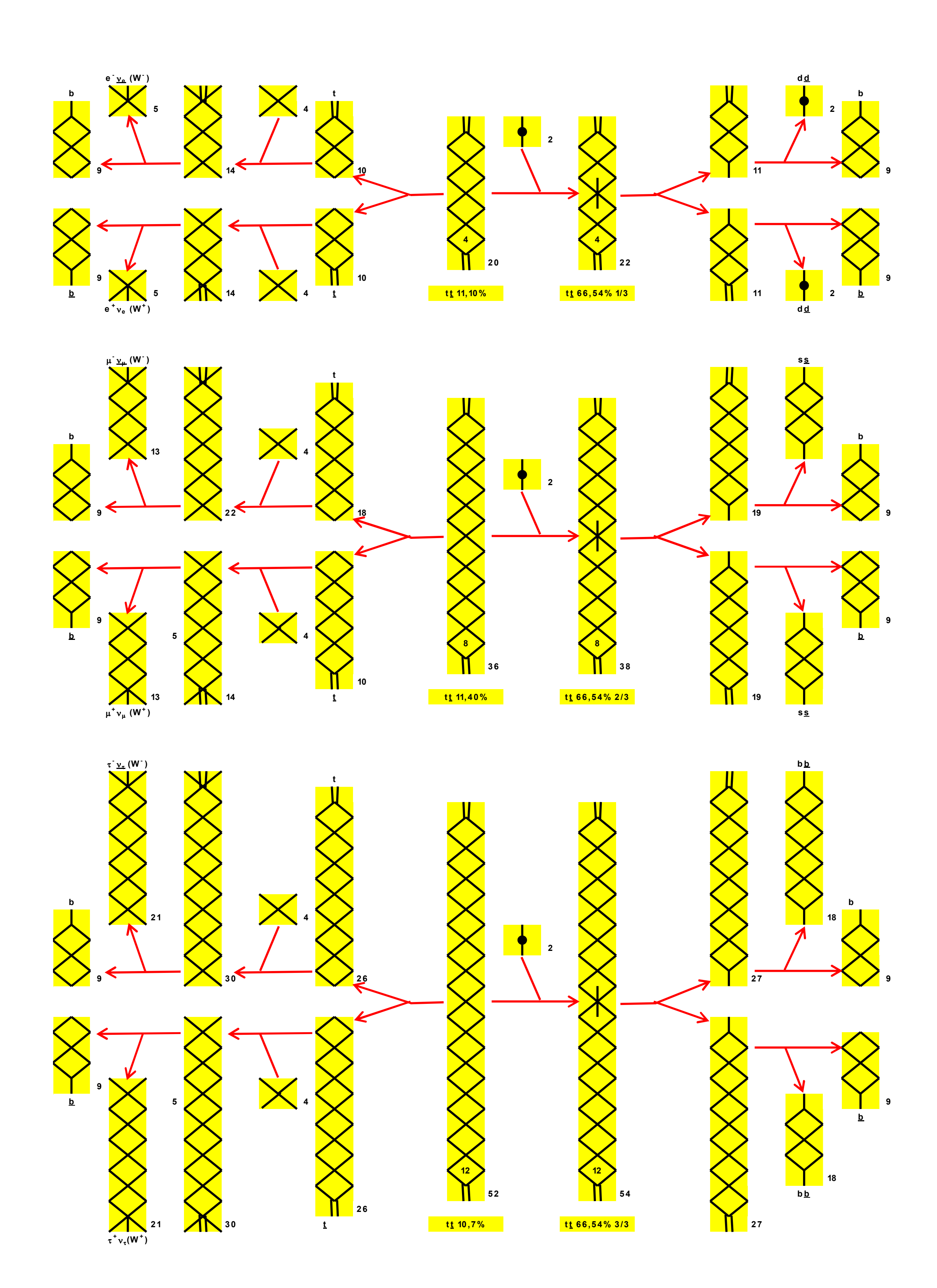
Full width $\Gamma = 1.42^{+0.19}_{-0.15}$ GeV (S = 1.4)

t DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$W q (q = b, s, d)$				–
$W b$				–
$e \nu_e b$		(11.10±0.30) %		–
$\mu \nu_\mu b$		(11.40±0.20) %		–
$\tau \nu_\tau b$		(10.7 ±0.5) %		–
$q \overline{q} b$		(66.5 ±1.4) %		–
$\gamma q (q=u,c)$		[c] < 1.8 × 10^{-4}	95%	–
$\Delta T = 1$ weak neutral current ($T1$) modes				
$Z q (q=u,c)$	$T1$	[d] < 5 × 10^{-4}	95%	–
$H u$	$T1$	< 1.2 × 10^{-3}	95%	–
$H c$	$T1$	< 1.1 × 10^{-3}	95%	–
$\ell^+ \overline{q} \overline{q}' (q=d,s,b;\ q'=u,c)$	$T1$	< 1.6 × 10^{-3}	95%	–

$e \nu_e b$	(11.10±0.30) %
$\mu \nu_\mu b$	(11.40±0.20) %
$\tau \nu_\tau b$	(10.7 ±0.5) %
$q \overline{q} b$	(66.5 ±1.4) %



tt 11,10%
2
tt 66,54% 1/3
4
20
4
22
tt 11,40%
tt 66,54% 2/3
2
8
36
8
38
tt 10,7%
tt 66,54% 3/3
2
12
52
12
54


e⁻ νe (W⁻)
b
5
4
t
d d
2
b
9
14
10
20
22
11
9
4
4
9
5
14
4
10
11
2
9
b
t
e⁺ νe (W⁺)
t t 11,10%
t t 66,54% 1/3
d d
μ⁻ νμ (W⁻)
s s
t
b
b
13
4
2
9
22
18
19
9
9
5
4
8
8
9
36
38
13
14
10
19
b
t
b
μ⁺ νμ (W⁺)
t t 11,40%
t t 66,54% 2/3
s s
τ⁻ ντ (W⁻)
b b
t
b
b
21
4
18
2
9
30
26
27
9
9
5
4
9
b
b
12
12
18
21
30
26
52
54
27
t
b b
τ⁺ ντ(W⁺)
t t 10,7%
t t 66,54% 3/3

$\gamma q(q{=}u,c)$ 1.8 $\times 10^{-4}$

4 4
b 10 c 6 u 2

$\ell^{+}\overline{q}\overline{q}'(q{=}d,s,b;\ q'{=}u,c)$ 1.6 $\times 10^{-3}$

e^- 3
4 0 8
10 14 14 5 s
6 c

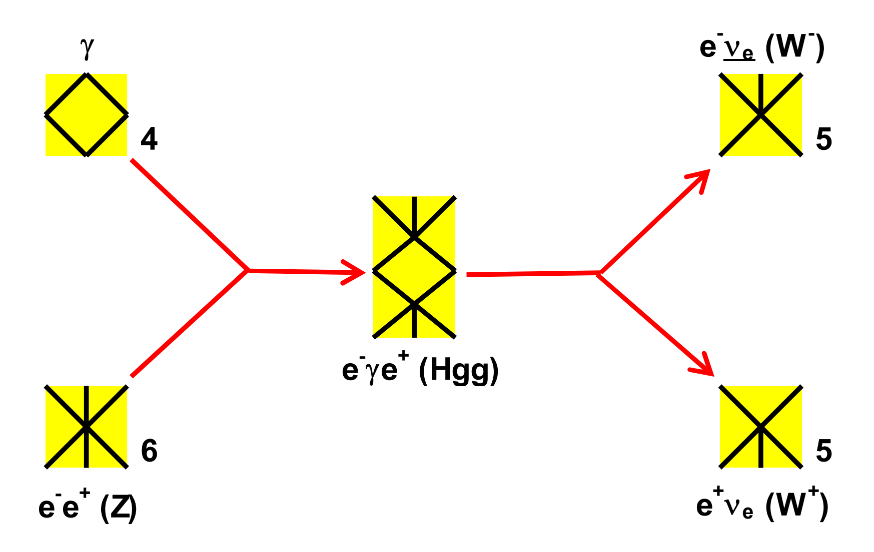
e^- 3
4 0 12
10 14 14 9 b
2 u

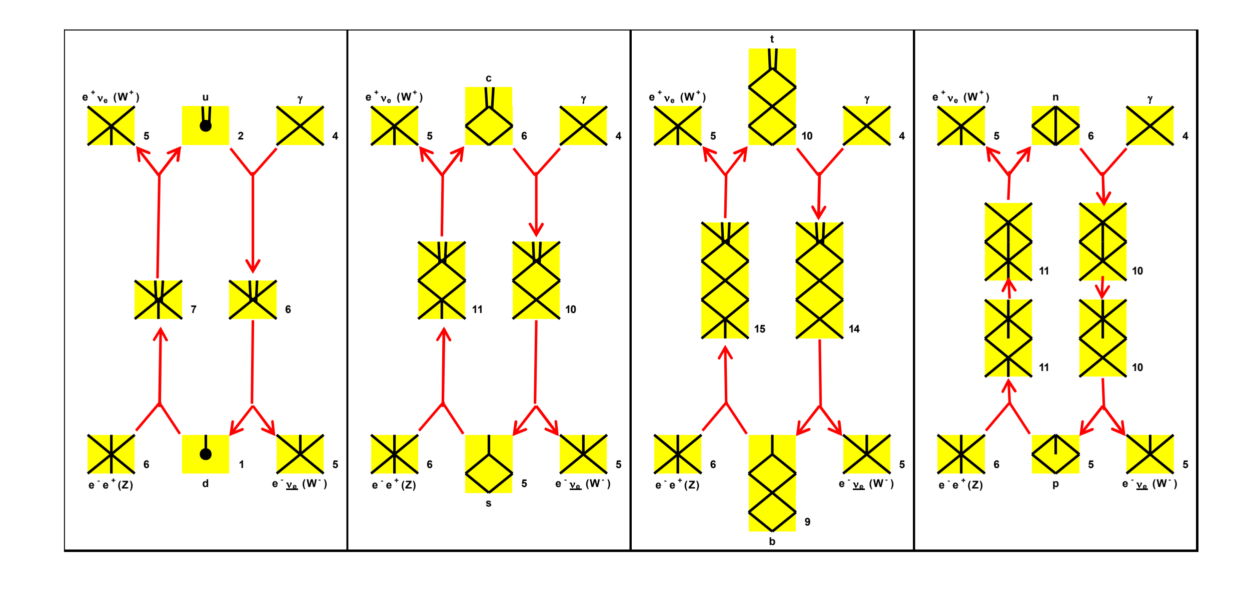
$Z q(q{=}u,c)$ 5 $\times 10^{-4}$

$e^- e^+$ (Z)
2 0
10 12 12 12
c

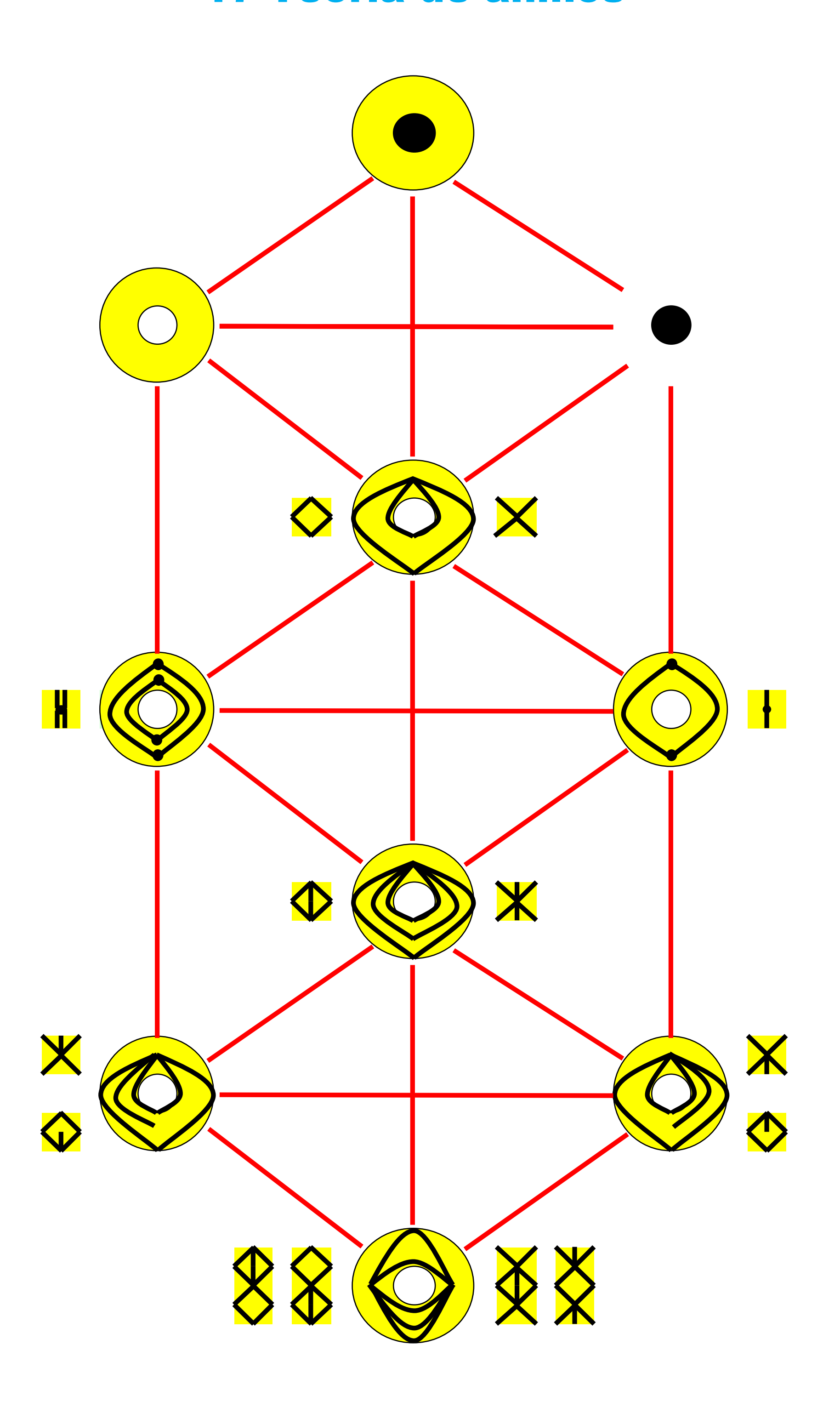
$e^- \mu^+$ (Z)
2 0 10
10 12 12 12
2 u

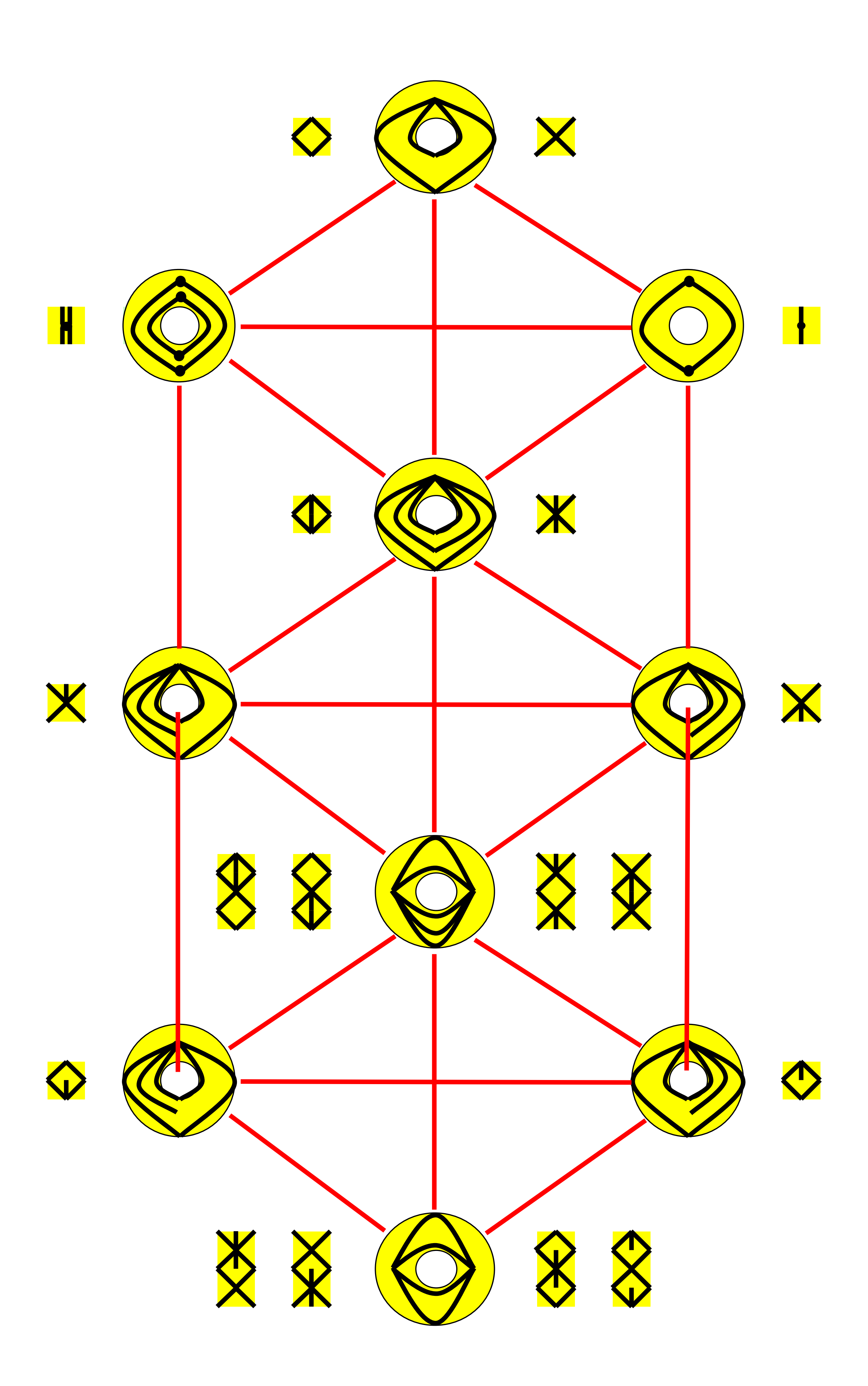
16 Interconversión de bosones

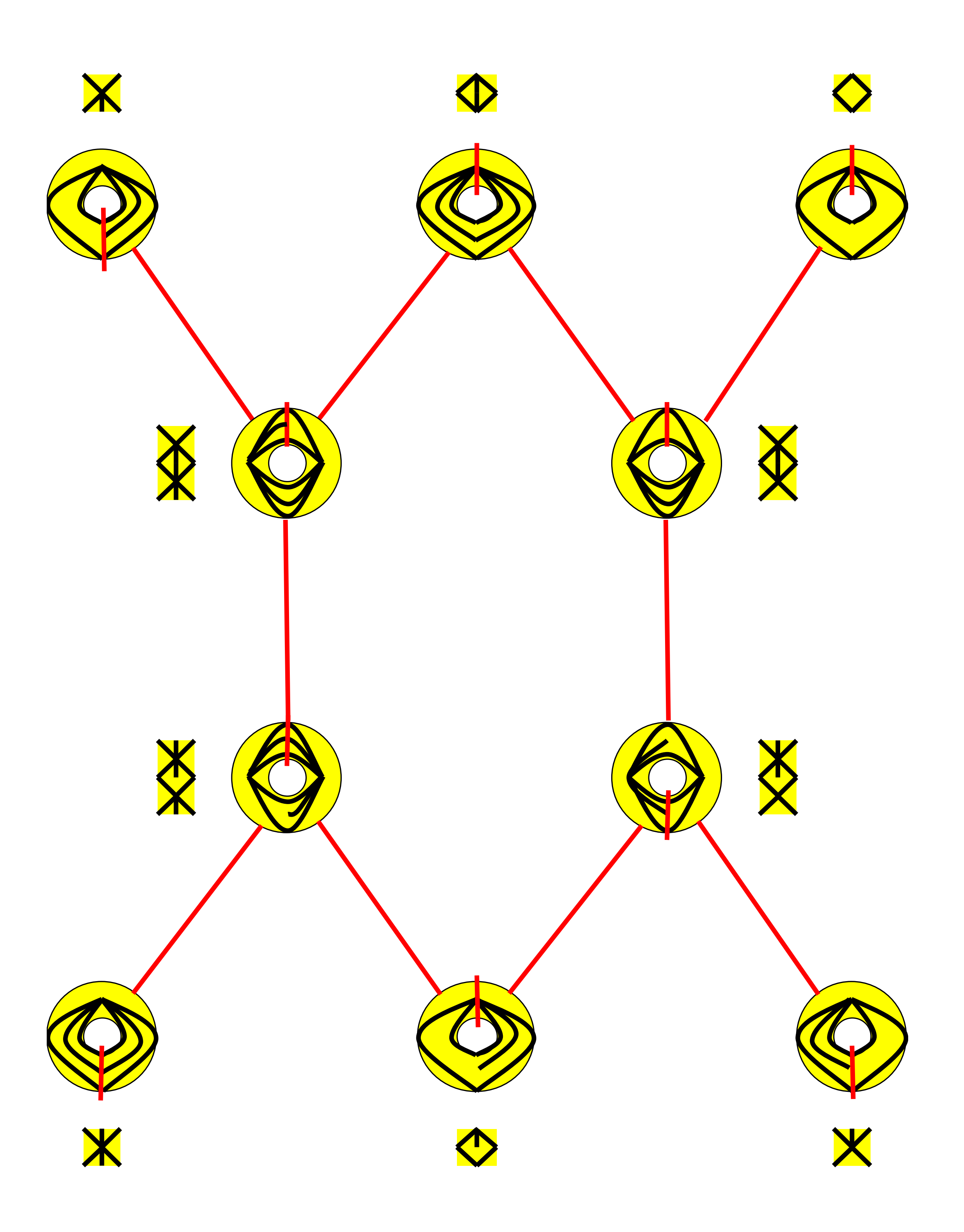


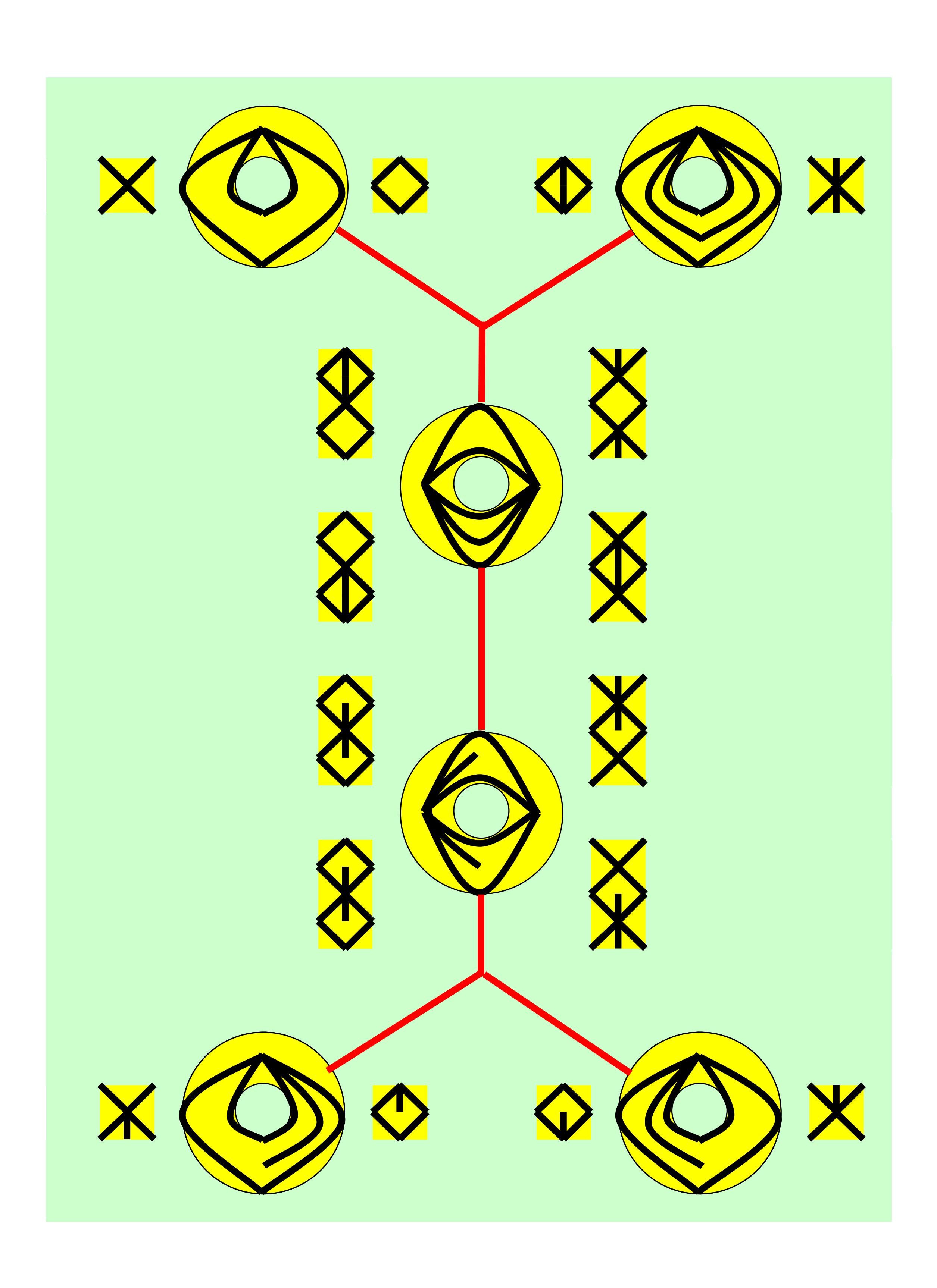


17 Teoría de anillos

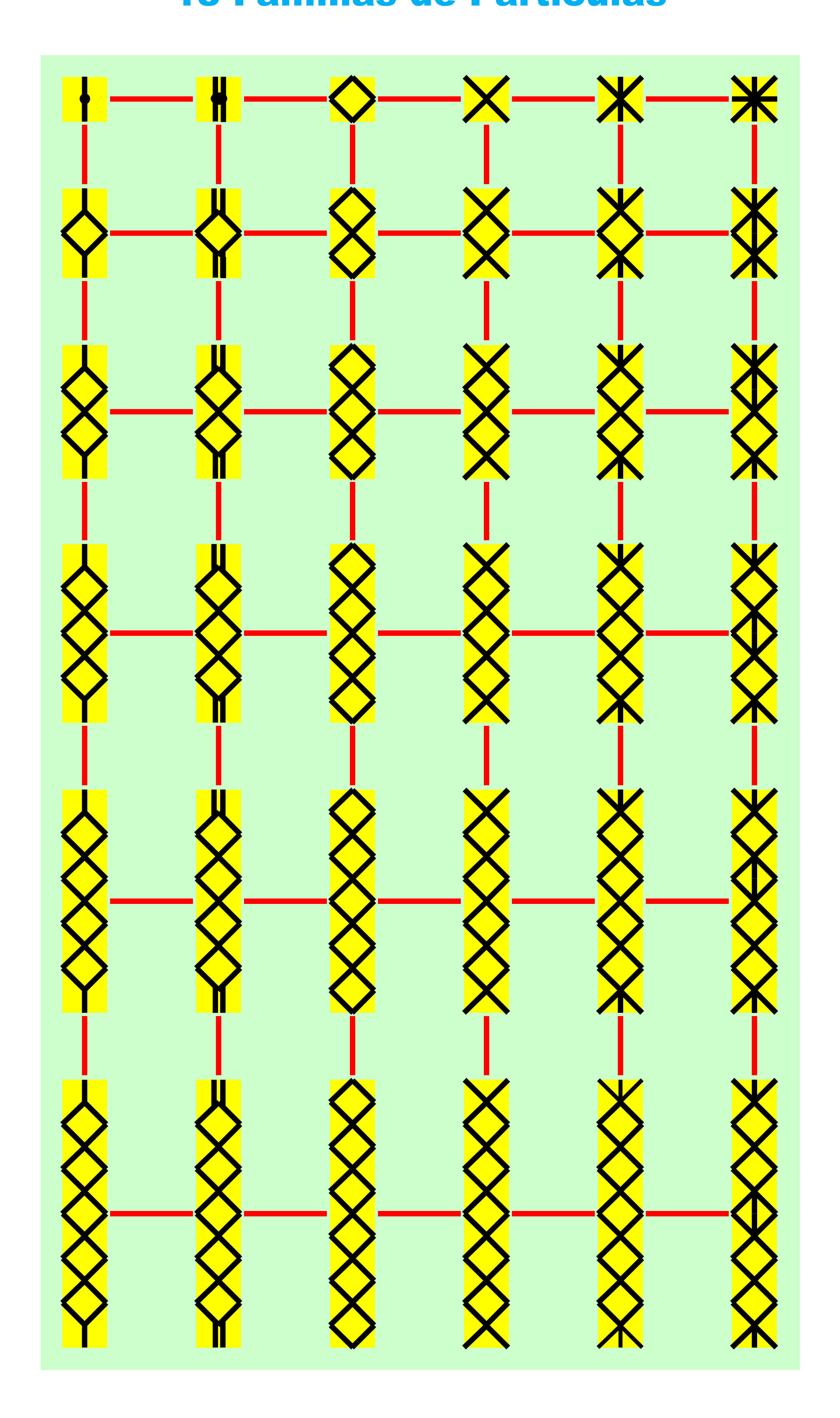


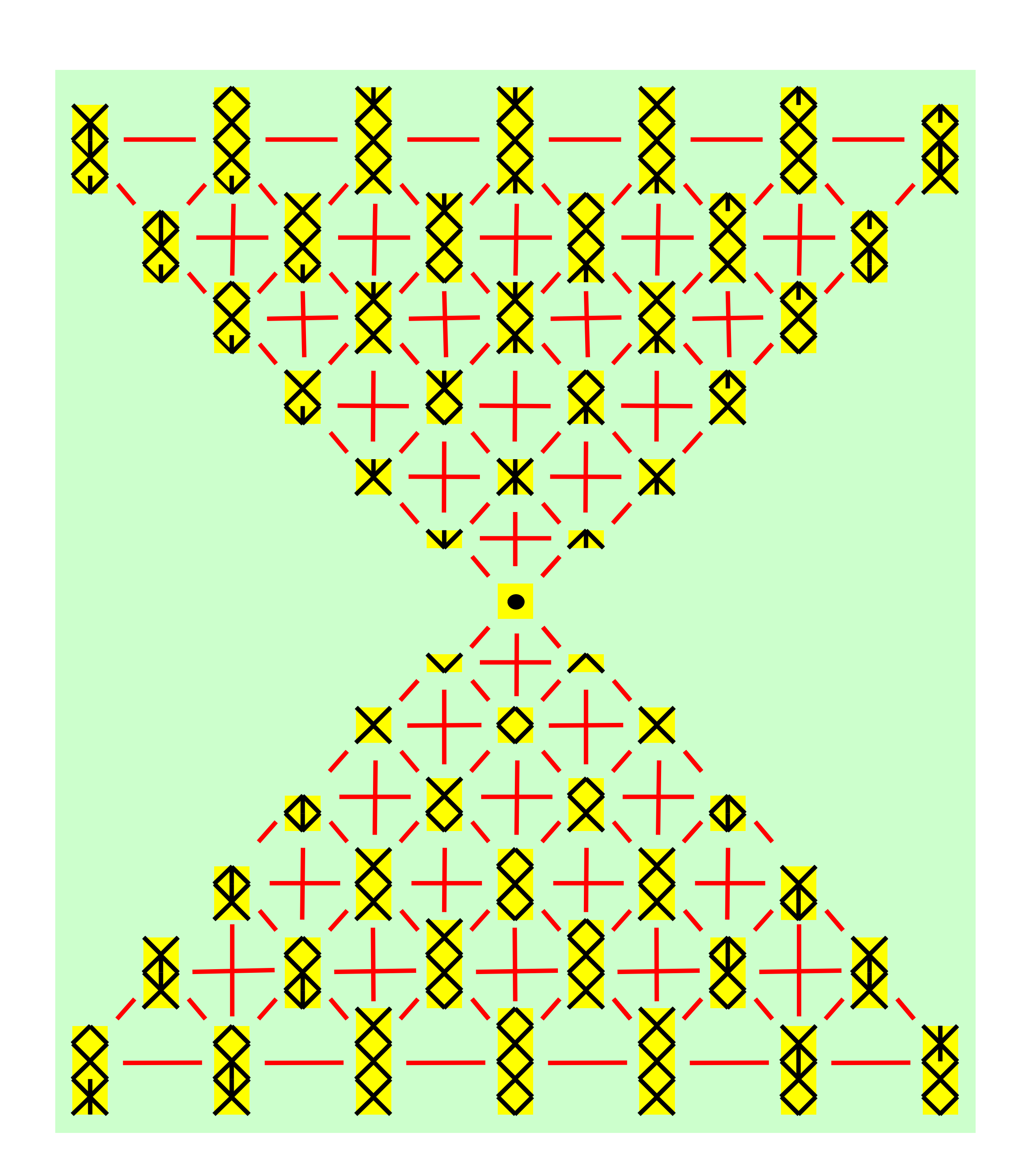


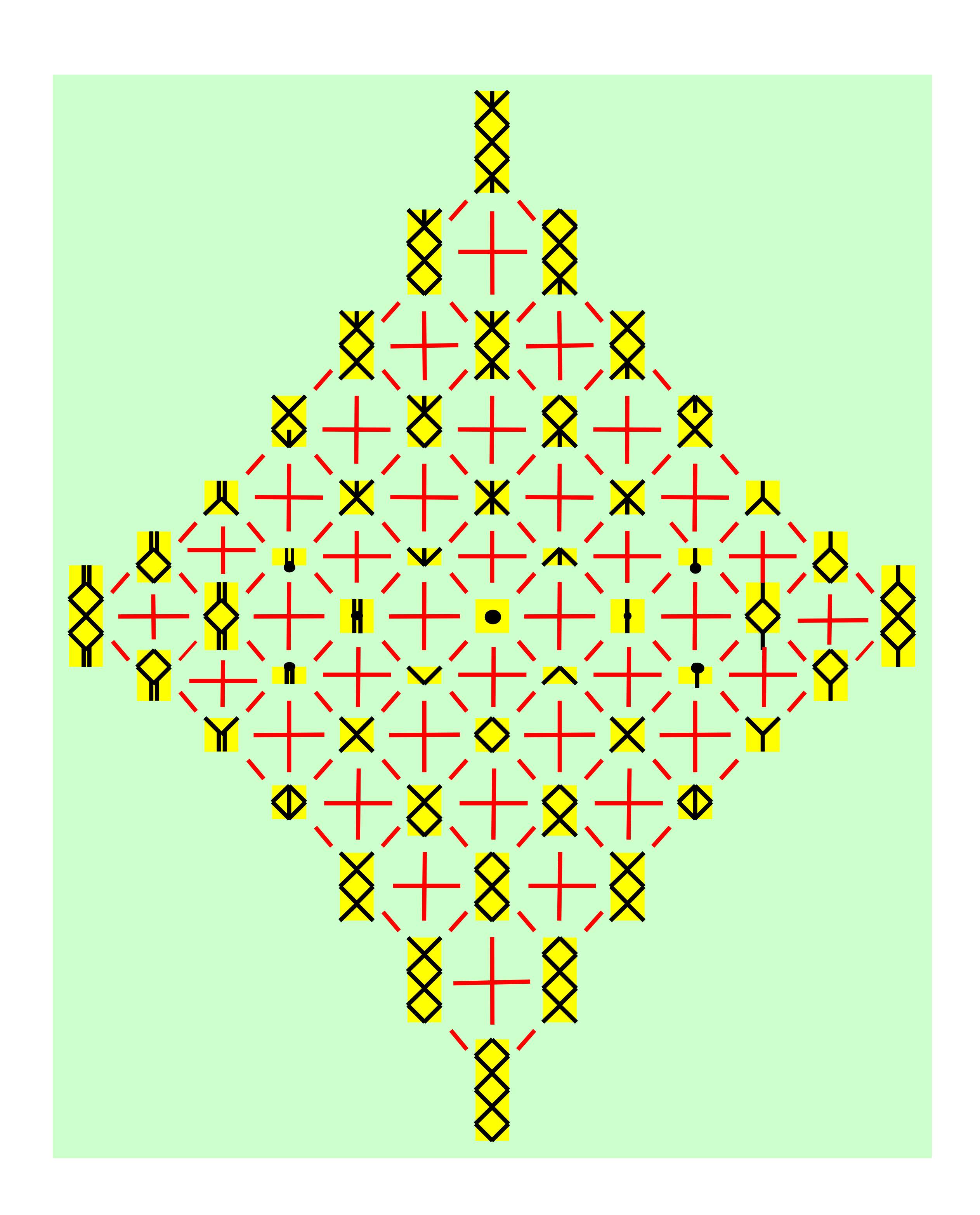


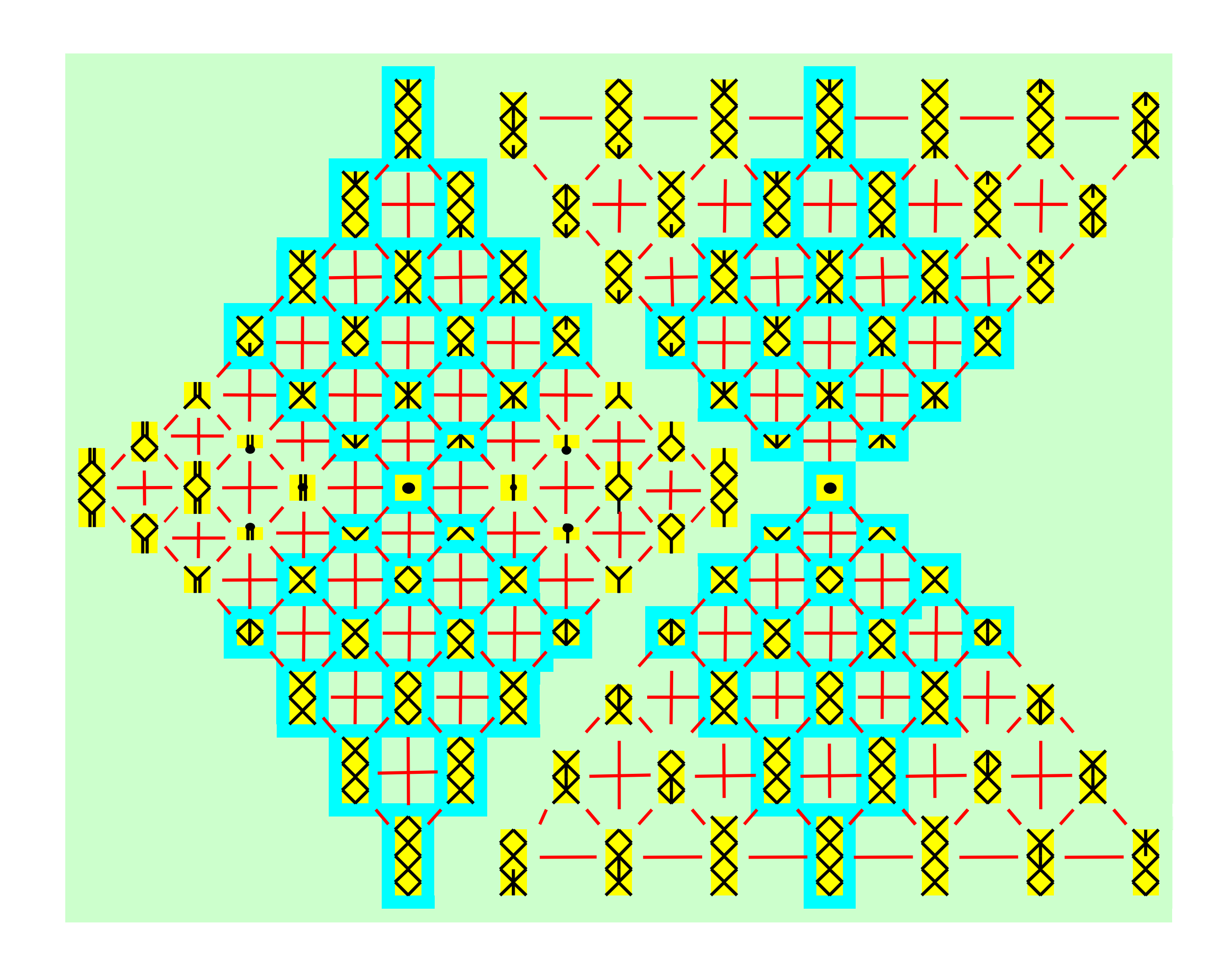


18 Familias de Partículas



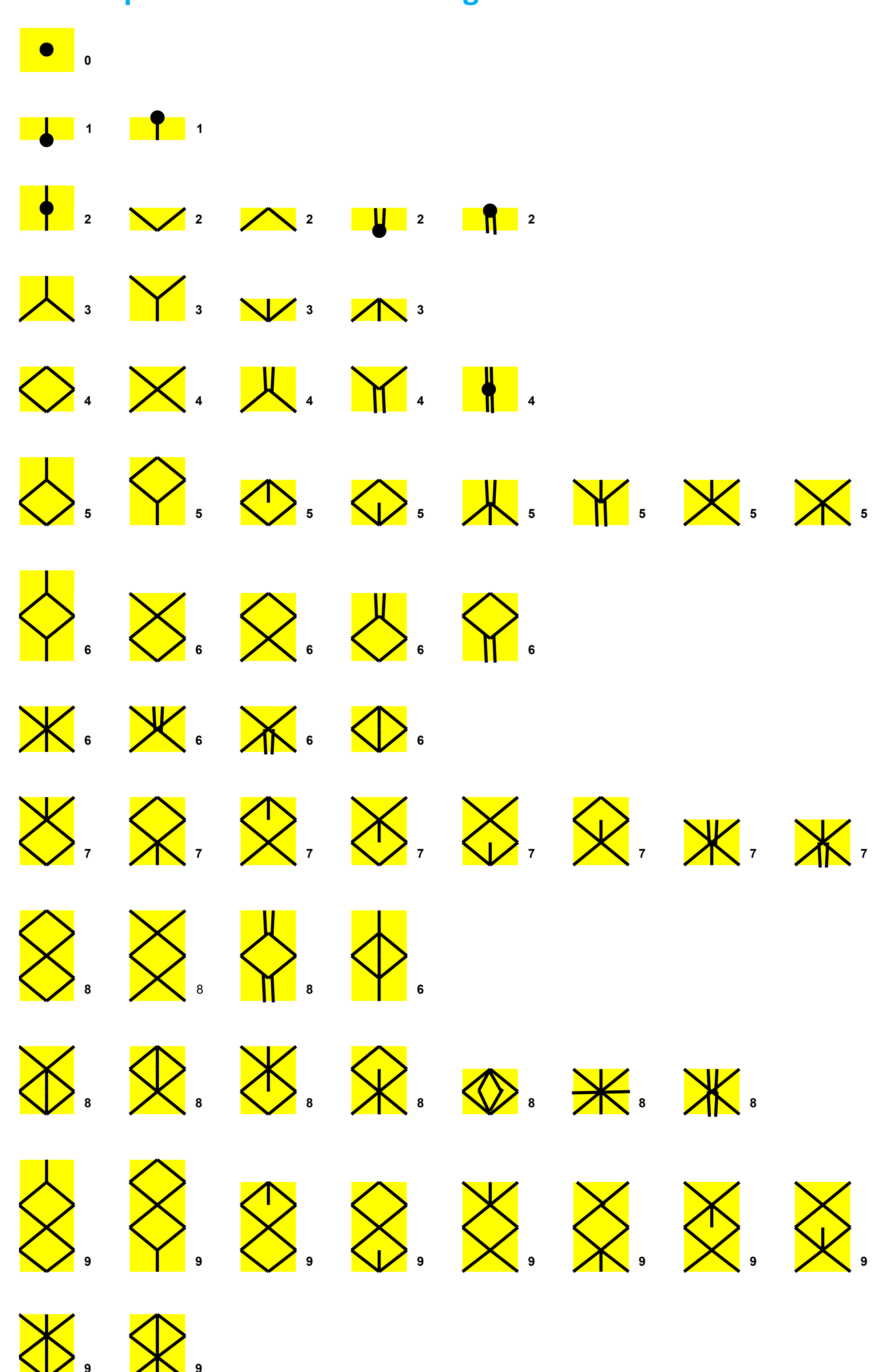


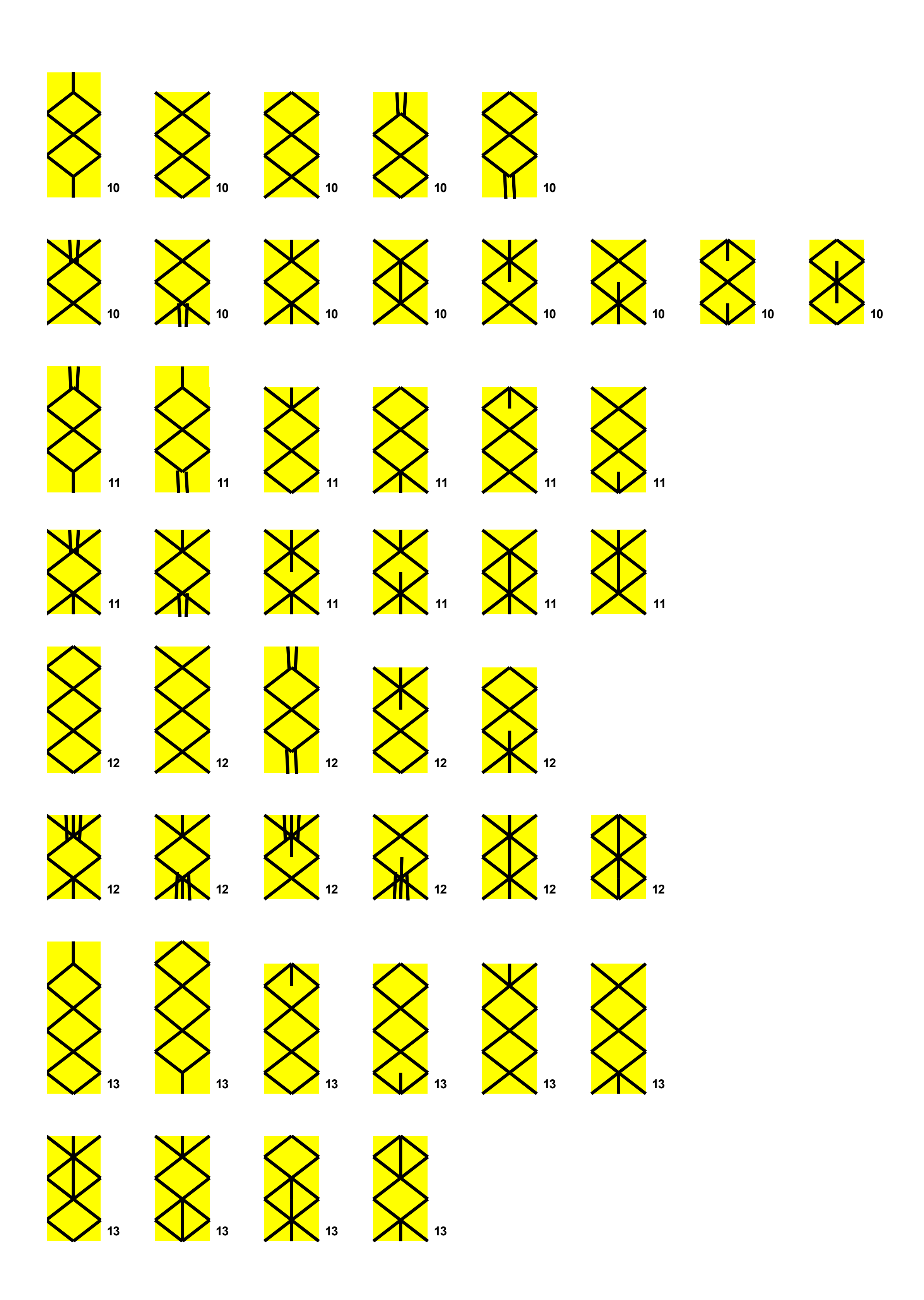


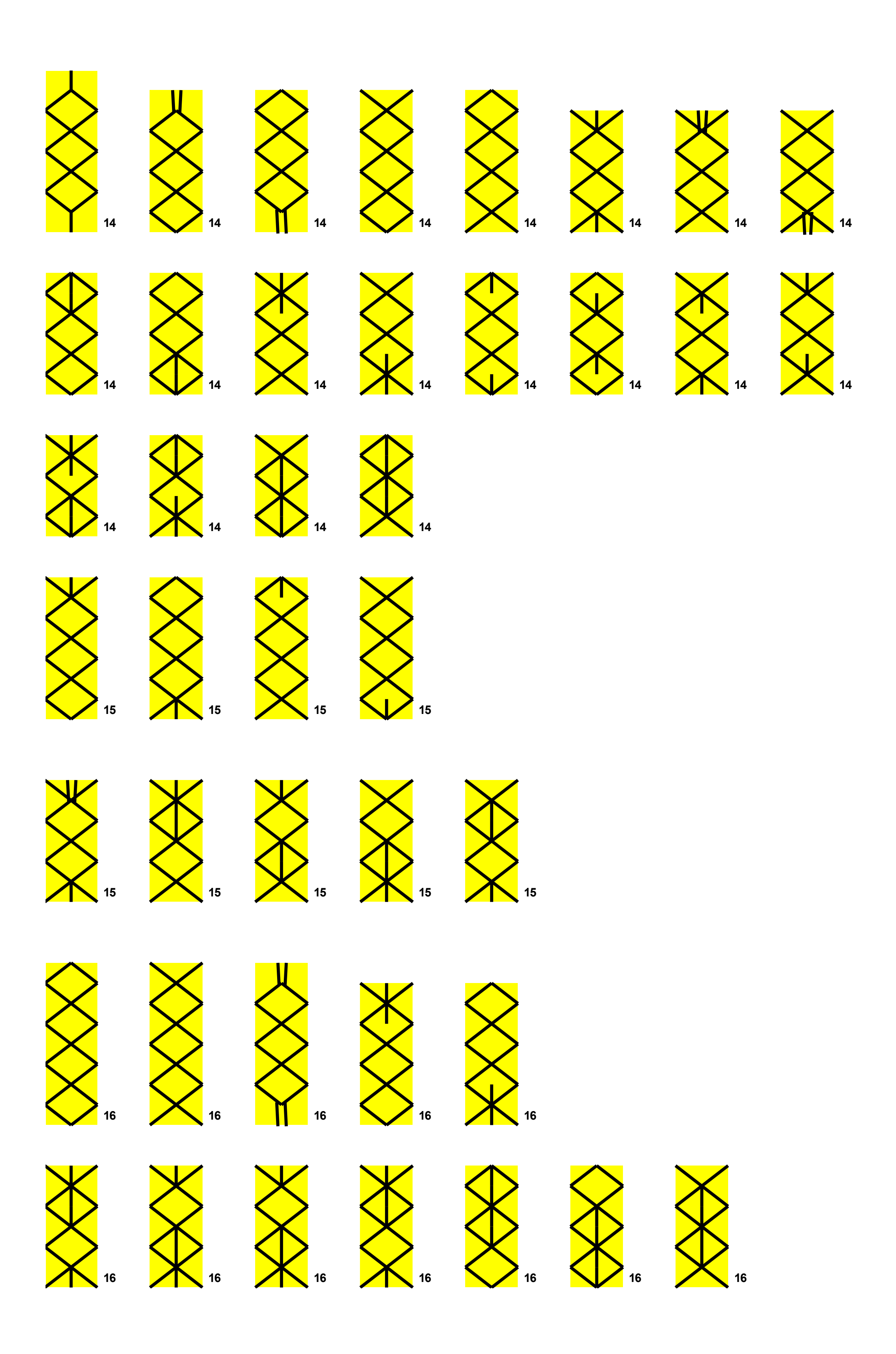


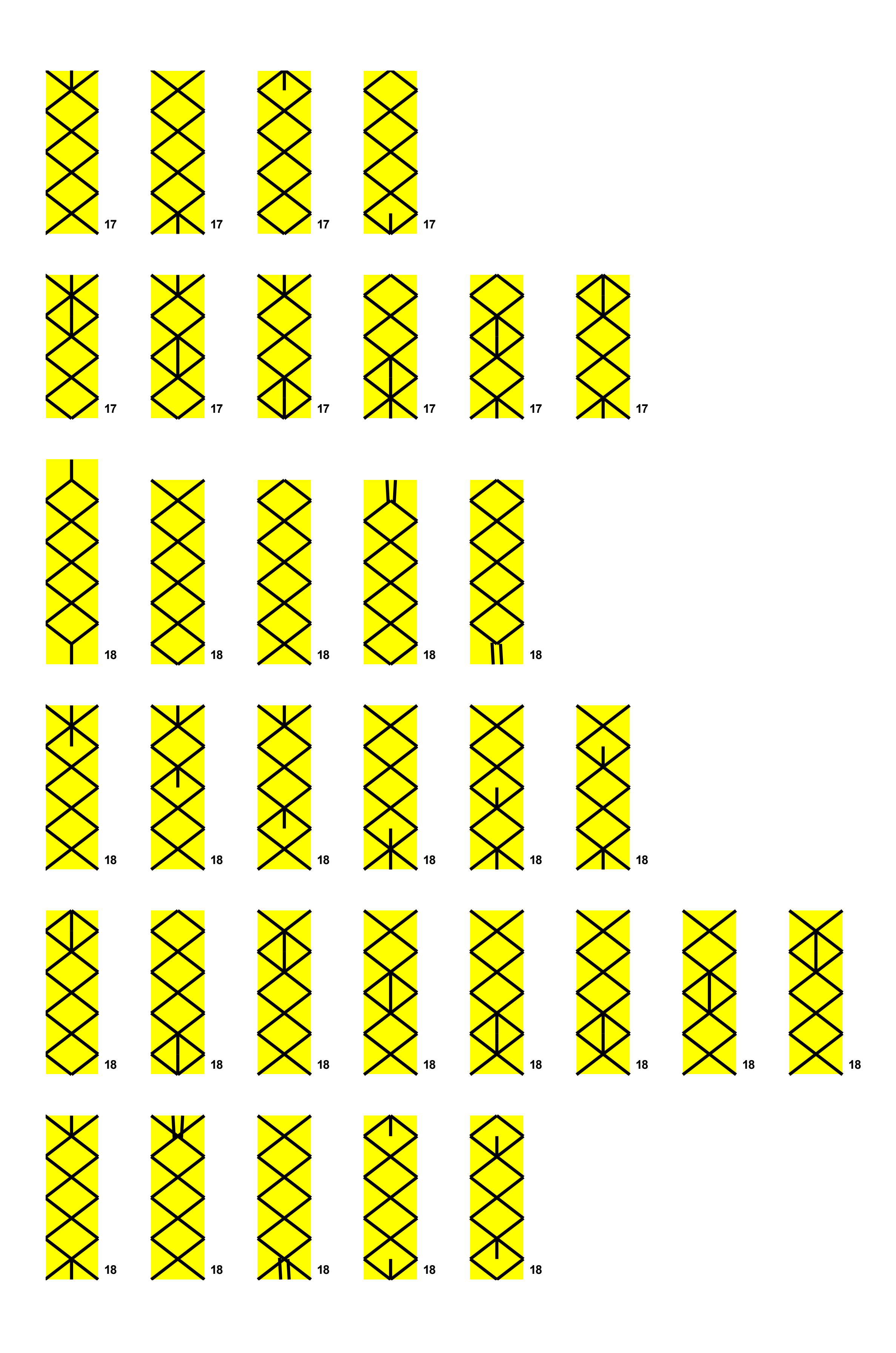
19 Índice de partículas

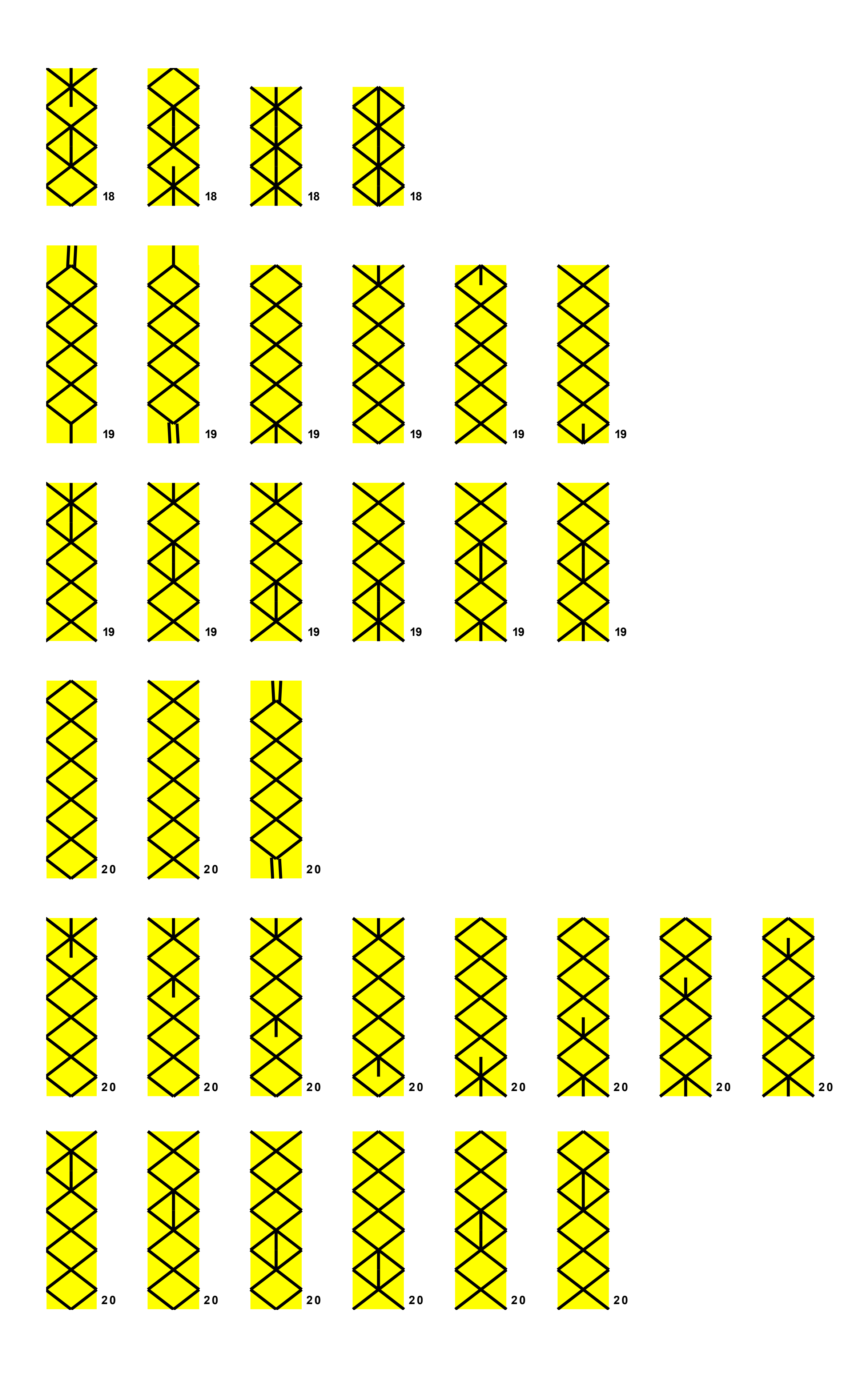
294 partículas ordenadas según el número de cuerdas

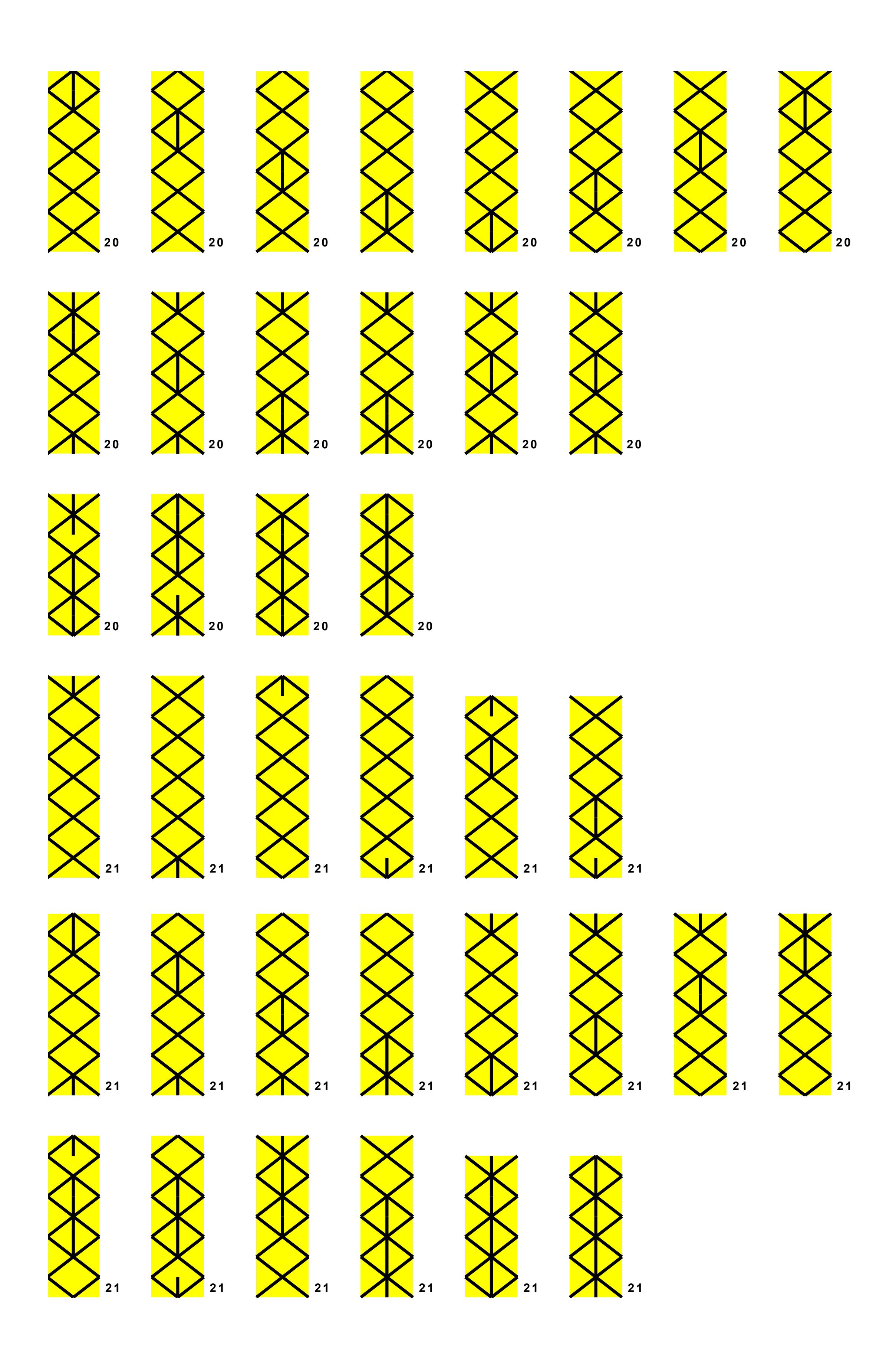


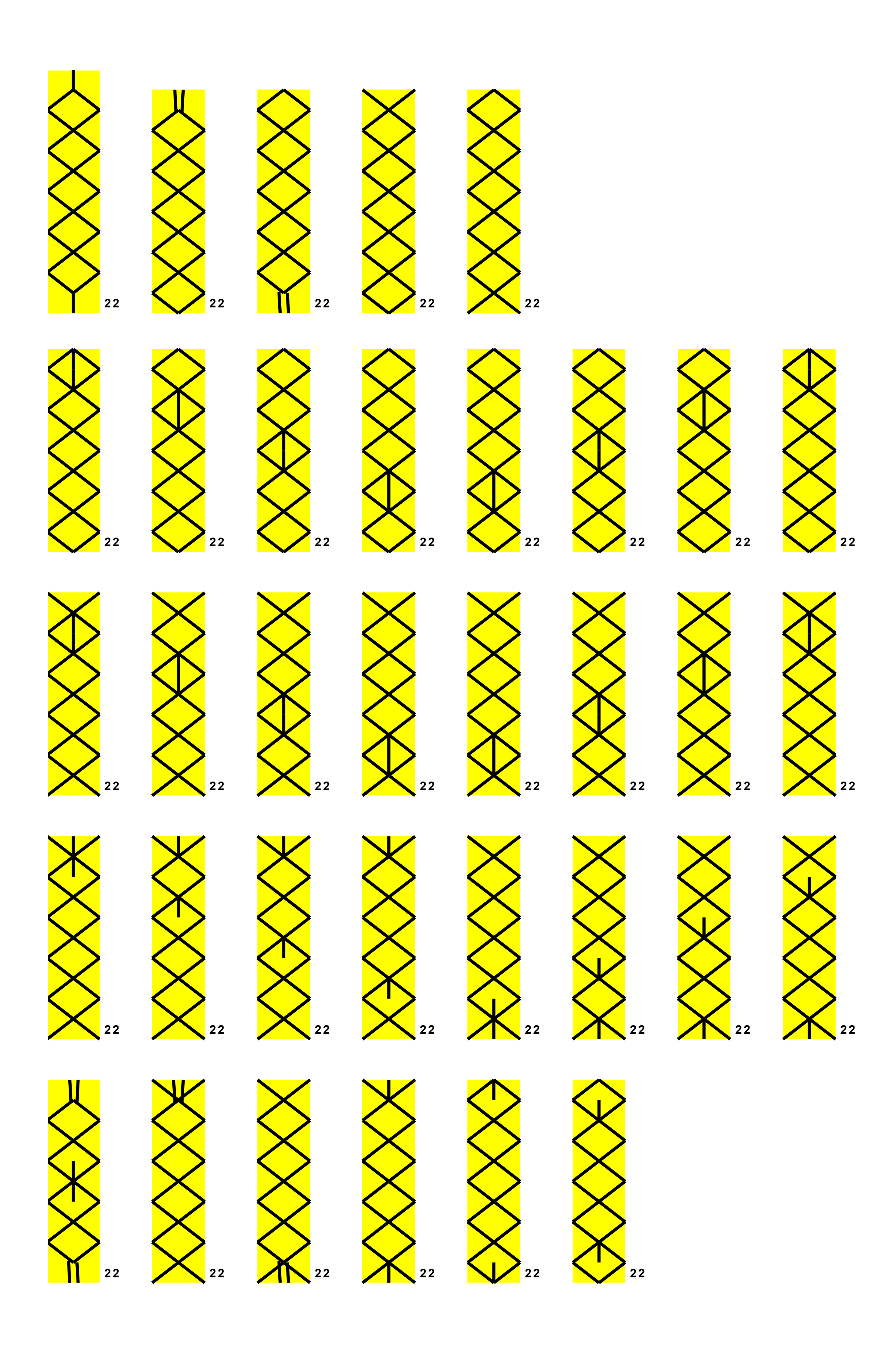

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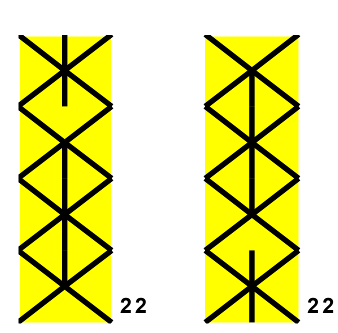

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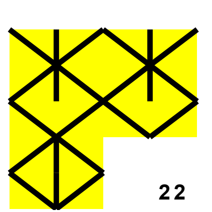

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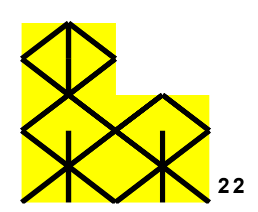

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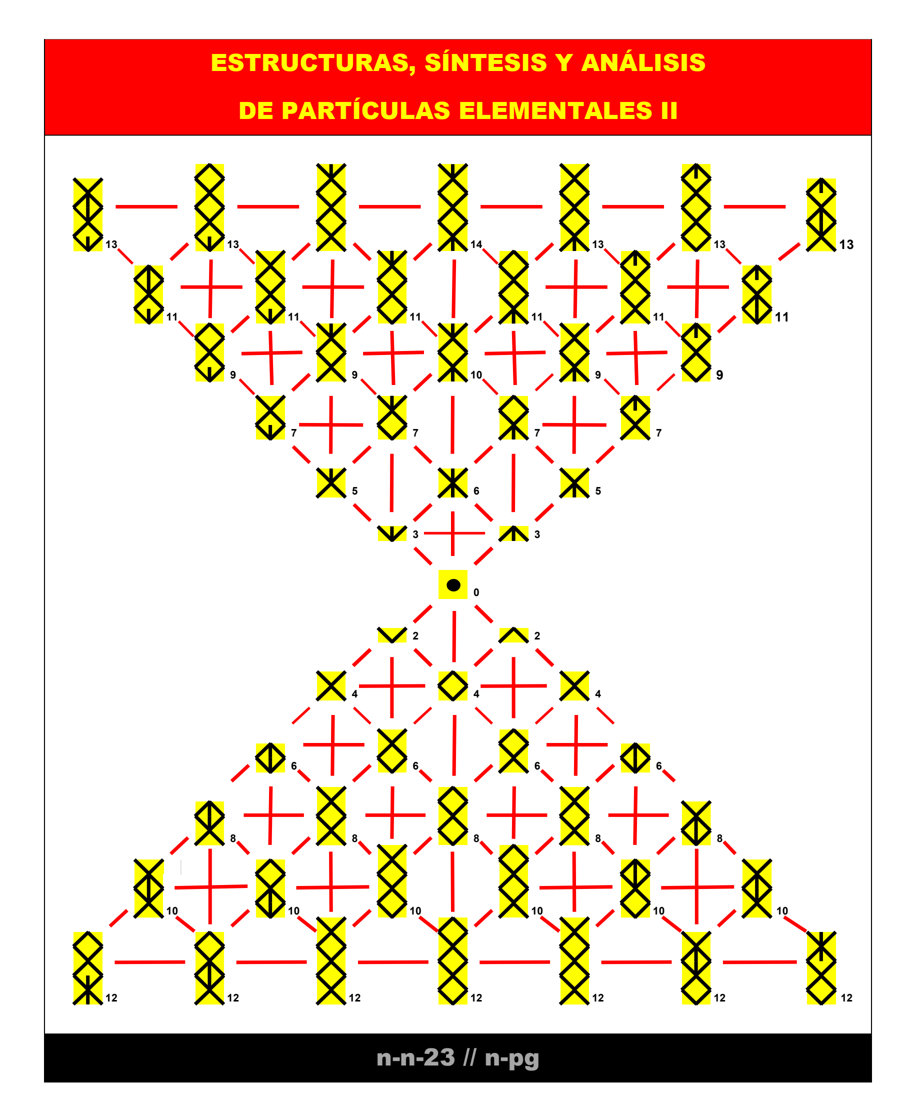

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